

The Elizabeth Kenny Institute, Minneapolis

The Kenny Concept of

INFANTILE PARALYSIS

and Its Treatment

by

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in collaboration with

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with a Foreword by

FRANK R OBER, M D

President The American Orthopedic Association

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DEDICATION

With sincere appreciation, this work is dedicated to

DR. WALLACE H COLE,

Professor of Orthopedic Surgery, Medical School of the University of Minnesota, in recognition of his efforts to investigate, test and finally approve of the Kenny concept and treatment of the disease anterior poliomyelitis, herein described and presented by Dr John F Pohl, Orthopedic Surgeon, Minneapolis General Hospital

ELIZABETH KENNY

IN APPRECIATION

I wish to extend my sincere thanks to

DR MILAND E KNAPP *and*
DR JOHN F POHL

for interest displayed in my work during the past two and a half years—their close association and assistance given in presenting the concept and treatment to their colleagues throughout the United States of America and elsewhere

I also wish to extend my thanks to the National Foundation for Infantile Paralysis for its financial aid without which it would have been impossible to have made this work available

ELIZABETH KENNY

FOREWORD

THIS volume on Infantile Paralysis is an up to date discussion of the techniques now being advocated by Sister Elizabeth Kenny The reader will find a well conceived plan for the relief of pain and muscle spasm by the early and continued use of hot packs and a well defined plan for re education of the neuromuscular system

The idea of moist heat is not new since one will find in the writings of Lovett and his coworkers that hot packs were advocated and used in 1916 and were found to relieve the deep pain and tenderness that is associated so often with this disease However they were used only two or three times a day and for one half hour periods and the patients were not seen until after the quarantine period

The method for the application of hot packs as used by Sister Kenny begins when the diagnosis is made and the packs are applied as described in the book for the relief of muscle spasm There is no doubt in my mind that by this method the pain disappears more quickly than by any other and stiffness is avoided

Sister Kenny puts great emphasis on muscle spasm in the affected muscles One does not find mention of muscle spasm in textbooks but there is no doubt that it is present and is a great factor in the production of early deformities unless relieved

Mental Alienation of muscles is another term used in the book and does occur even in other conditions in which there is no paralysis

Braces and splints are not used to prevent early deformities since they make extremities stiff and increase muscle spasm If the Kenny technique, with its continuous superb nursing, is followed, the physician will find that the affected parts become soft and relaxed, limitation of motion is not so persistent, and pain subsides remarkably early as compared to other methods The physical therapist will find that close application of the technique described in the book will gain the maximum amount of recovery more quickly and much more satisfactorily than by the techniques previously employed

It is my personal belief that this book should be perused and used by all interested in the welfare of those who are afflicted with poliomyelitis

FRANK R OBER, M D

President The American Orthopedic Association John B and Buckminster Brown Clinical Professor of Orthopedic Surgery Assistant Dean in charge of courses for graduates Harvard Medical School

A STATEMENT

Sister Elizabeth Kenny has found in the United States exactly that combination of circumstances necessary for the success of her work Here were cases of infantile paralysis, here was a progressive and sympathetic medical profession, here were many scientists studying basic problems of this baffling disease, and above all, in the United States there was a National Foundation for Infantile Paralysis to lead and direct the fight

During the first three decades of her work in Australia and England a great many listened to the story of Sister Elizabeth Kenny, and but few were convinced that her treatment was good Never, before coming to the United States was she able to work side by side with clinicians, scientists, research workers, preparing a complete and connected picture of her ideas and methods The anatomists, physiologists pathologists, as well as pediatricians, orthopedic surgeons, and men in physical medicine have studied her results and her methods

In medicine it is not well to believe the eye alone Miss Kenny's patients were apparently far better than those treated by other methods But why? Could the results be duplicated? Could the work be taught to others and carried on elsewhere and under different conditions? These and many other questions had to be answered before the American physicians and the American public could be expected to accept the evidence of their eyes and to be certain this was not legerdemain or mere chance

The National Foundation for Infantile Paralysis has sponsored and directed a broad program of research in connection with Miss Kenny's work Not only has it supported Sister Kenny and her staff at the University of Minnesota, but it has financed other investigative and instructional programs in many laboratories, medical schools, and hospitals throughout all of the United States Not only do those immediately concerned with the treatment of the acute case of infantile paralysis approve of Miss Kenny's method, once they have mastered the intricacies of it, but also those who work in the laboratories with problems on histopathology, anatomy, and physiology claim that the major concept is reasonable and rational

In centers from coast to coast the work is being taught to new workers More and more doctors, nurses and physical therapy technicians are learning to apply successfully the treatment methods described in this book

This forward step is not a new treatment for the disease as previously conceived but presents an entirely new concept and a satisfactory treatment for this concept Consequently, many of the handicapping physical defects have been eliminated We are therefore thankful that much that once was accepted as necessary deformity now can be overcome However, this to us is not enough and there must be found ways of preventing the spread of the virus of infantile paralysis, ways of preventing damage to those exposed to the infection and methods of increasing individual resistance and to this end the National Foundation shall go forward to final victory

BASIL O'CONNOR

President
The National Foundation for Infantile Paralysis Inc

PREFACE

Sister Elizabeth Kenny

THRICE ten years have elapsed since I a lone worker in the bush of Australia came in contact with the disease known as infantile paralysis At this time I was unacquainted with the orthodox concept of this disease and its treatment and was advised by the medical man from whom I sought council (the late Dr Aeneas John McDonnell) that there was no known treatment for this disease in the acute stage and to do the best I could with the symptoms presenting themselves Looking at the patients, I saw that there was an involuntary shortening of certain muscles of the body I also noticed that this shortening was brought about by painful contractions also involuntary, therefore, spasmodic I found upon attempting to rectify this condition by efforts to replace the limb in natural alignment that the condition became exaggerated and instead of relaxing the shortening muscle, the patient resented the effort and became fearful of being touched and the condition became worse I also noticed that this shortening prevented contraction of the opposing muscle thus preventing any movement by normal flexion and extension abduction or adduction My

deductions were that the muscle that was being subjected to this painful and spasmodic contraction was in some way affected by the disease and presented a condition that needed treatment In short, the muscle was sick and needed nursing, for not only was it pulling the skeleton into a state of deformity, but it was also preventing the opposing muscles from contracting by putting this brake upon their action Therefore, my first objective was to speedily get rid of this painful condition and allow relaxation to occur

In order to accomplish this I applied heat in various forms—first, by heating salt in a pan and putting the heated salt in a bag and placing it upon the parts affected I found that this was too heavy for the patient to bear and the dry heat did not appear satisfactory My next effort was a poultice made of linseed meal which after twenty four hours I also ruled out, for to get it hot enough without using too much boiling water was too difficult and the weight was too much My third attempt was to wring light woolen material out of boiling water as dry as possible and put a light protective material on top This was the most satisfactory procedure and the patient frequently requested the renewal of these foments and I had the great pleasure of seeing relaxation occur The joint could be moved through a normal arc and deformities corrected However I found that the muscle which had been pulled from its normal resting length had forgotten how to contract and must be taught over again

My next endeavor was to attempt to connect the mind to the tendon of this alienated muscle Remembering that consciousness is born from the subconscious,

I endeavored to bring consciousness about by attempting to bombard this area with impulses from the surrounding muscles For instance if the hamstrings were alienated from consciousness I would grasp the foot firmly and lightly with my hand, tense the muscles of my arm tightly and cause a vibratory contraction in the muscle belly of the gastrocnemeii from their origin The origin of this muscle is in the region of the insertion of the hamstrings and I would attempt to restore the reflexes to the tendon of the alienated muscle This procedure was practised until I was requested to teach others the system I then found it was too strenuous for the technician and substituted the procedure explained in this treatise, which I have found to be as beneficial

At this time I also found that through some disorganization there was an interruption in the normal flow of impulses and that the patient could not visualize in space the exact area from which an attempt to contract should materialize, and the impulses ran riot as it were For instance instead of an even rhythmic contraction from the point of insertion the muscle would strongly contract at the origin and lose strength before the impulses reached the insertion Therefore, the brain path must be very carefully restored and rhythm established

Thus were the symptoms—spasm alienation and incoordination in this disease known as infantile paralysis, discovered thirty years ago

From time to time certain patients were treated under the supervision of different doctors in Australia in the years that followed These patients were long standing cases and had apparently come to a standstill

but with the change of treatment certain improve ment was seen to be brought about This improvement was sufficiently encouraging to warrant the medical supervisors suggesting that it would be advisable to inquire further and *have this knowledge transmitted* to others in order to insure its perpetuity

A meeting was called at the Brisbane General Hospital at which I was requested to present my ideas At this meeting I attempted to explain that *there was a muscle condition which required treat* ment and that the accepted theories with regard to this disease were in my opinion incorrect I attempted to explain these symptoms pointing out that if relaxa tion is not brought about the muscles remain for the *most part contracted My first effort was to explain* that the neck rigidity was caused by this spasm in the posterior neck and could be detected by the exag gerated groove in this area starting at the base of the skull However the reception of this statement was markedly hostile and in the evidence presented by the Director of Health of the State of Queensland Sir Raphael Cilento and Dr Harold Crawford President of the Massage Association of the State of Queensland Chairman and Vice Chairman of this meeting refer ence is made to what they termed this ridiculous statement This was in the year 1933 (See report *of the Royal Commission of Investigation Queens* land Australia) At this same meeting in the year 1933 I attempted to explain that the alienated muscles re quired stimulating in order to restore awareness of the part and demonstrated the method I then used for *this procedure* This matter is referred to in the report presented by Dr R Dungan issued in September

1934 On page 3 of this report the following statement was made

> "The outstanding feature in her method of treatment is what she calls vibratory treatment
> 'This consists of holding the part in certain positions mainly at insertion of tendons and muscles, with a firm grip but *not* transmitting heavy pressure to the deeper structures
> "To do this the operator firmly contracts his own muscles which quiver and transmit a vibration to the muscles and joints that are instrumental in the movement desired"

This description was given by Dr R W Dungan exactly nine years ago and is recorded in the report of the Royal Commission, page 12 However, the impressions of the group at the meeting already referred to, held at the Brisbane General Hospital in the year 1933, were recorded by Dr Harold Crawford and a statement that this was a damaging procedure was also recorded No doubt, this conclusion was reached owing to the fact that the senior child's specialist present asked me what effort did I put into the procedure and I replied, "All I possess" No doubt, Dr Crawford deducted that this pressure was put upon the patient instead of the muscles of the operator However, Dr Dungan was associated with the work and emphasized in his report that heavy pressure was avoided I then used this effort to stimulate the reflexes from the receptor in the periphery to the proprioceptor and tendons However, I have already explained that I found this method too strenuous to teach and have substituted the method described in this book by Dr Pohl

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> spinal deformities are in fact hard to prevent. It is quite certain, however, that any system of treating Poliomyelitis that disregards the use of immobilization will reap a harvest of spinal deformities such as have not been seen since the days when the disease was treated on less logical lines." — (*Report of The Royal Commission On The Investigation of Infantile Paralysis, page* 41.)

At this time it was thought that to place a patient in my care would be placing it in incompetent hands, for in their final summing up it was stated:

> (1) Her abandonment of immobilization is a grievous error and fraught with great danger, especially in young children who cannot co-operate in re-education.
>
> (5) It would be particularly damaging to adopt the Kenny non-splinting method of treating early cases owing to its failure to prevent injury due to muscle stretching and deformity due to muscular imbalance. (page 52)

These statements were made without any observation of my work with infantile paralysis as I had attended it alone over twenty years prior to this date. Beds were not placed at my disposal in any hospital where I could point out the true symptoms of this disease to the medical observer, more especially that most damaging symptom, muscle spasm. The procedure in Australia and England at that time was with very little variations similar to that employed in the United States of America and all English speaking clinics throughout the world, and is summed up in the report already referred to in the statement:

Immobilization and re-education is the kernel

of all modern treatment for the disease infantile paralysis"

In the year 1937, immediately after the publication of my book, an opportunity arose for me to visit England which I accepted, and during my visit I was requested by the Director General of Health of the London County Council to demonstrate my work and teach technicians at Queen Mary's Hospital, Carshalton, England I again attempted to present to the committee of medical men appointed to observe my work the true symptoms of this disease Remembering the warning given to me in Australia that my ideas were so radical that my sanity would be questioned if I expressed them, I very cautiously introduced the concept of muscle spasm as a damaging symptom However, my remark fell upon barren soil The chairman replied, "This is a new one on us What do you mean?" And no further notice was taken This clinic received patients in the early convalescent stage but not in the acute stage A report from this work was published in the year 1938, and was one step nearer my goal When my first book was published, the reviewer of this book in the *British Medical Journal* stated "It was the abandonment of immobilization that was so startling A complete reversal of a long accepted theory" However, this overthrow was justified in a prominent statement made by this committee in their report, reading

> "Her abandonment of immobilization had not brought about any disaster neither was there any delay in the initial return of power * * * Expected deformities from muscle imbalance had not materialized"

This conclusion altogether confounded the statements made by the Royal Commission of Investigation However, it had not dawned on the minds of the observers to inquire why this paramount principle of orthodox procedures could be abandoned and no harm accrue However, I had to leave England without demonstrating the true symptoms of the disease and a treatment for these symptoms, but the work has continued just as I left it with seven full time physiotherapists employed, despite the war

In the years 1937 38, a severe epidemic occurred in the State of Victoria, Australia, and I was invited to visit this state to demonstrate my work to the government of the state It was at this clinic that I established the fact that the condition of muscle spasm was present In the report published in the year 1938, a statement is made by the medical observers, reading

> "Miss Kenny lays great stress on the condition of muscle spasm, its prevention and cure We think her views on this subject require careful consideration"

This report also stated that deformities from muscle imbalance had not materialized but had in their own splinted patients they, themselves, had treated or received from other surgeons They also commented upon the absence of stiffness in the patients treated by the Kenny method and added, "The reason why should be earnestly sought," for this stiffness also was troublesome in the patients treated by orthodox procedures and prevented satisfactory physiotherapy treatment from being given

Soon after this report was submitted I was given an opportunity of treating acute cases at the Brisbane

General Hospital A committee of medical men appointed by the New South Wales Hospital Commission visited this center and I pointed out to their satisfaction that the condition of spasm and incoordination existed It was then publicly acknowledged that I had evolved a satisfactory and commendable treatment for infantile paralysis in the acute stage which held out more hope for recovery than any other method known anywhere This announcement was made in December, 1939

Almost simultaneously with this announcement my attention was drawn to an article appearing in a July number of the *Journal of the American Medical Association* submitted by Dr K Hansson, New York Hospital for Ruptured and Crippled Dr Schwartz of Paris whose daughter had been a patient of mine, suggested that I follow this matter up as this paper contained the statement that

> "Nowhere in the world was there any specific treatment for this disease in the acute stage"

This paper also added that much had been accomplished in the treatment of this disease in the convalescent stage Dr Schwartz advised me to come to the United States At this particular time a certain amount of remorse had found a home in the hearts of some of the doctors who had affixed their signatures to the report of the Royal Commission of Investigation Although at this time there was not one member of the British Medical Association in Australia who knew my work, I was advised to come to the United States of America and every possible assistance was given by the government and the group of medical

men interested This has been explained in my book published in 1941

Since my arrival in the United States my work has been carried out at the City Hospital Minneapolis and at station 43, University of Minnesota Hospital Minneapolis I have from time to time visited other centers and given lectures in these centers Several lectures were given at the Willard Parker Hospital and the Orthopaedic Hospital both of New York City These lectures induced the supervising medical men to personally investigate the procedure and attempt to improve the results obtained in this disease with the assistance of my book I also visited the city of Winnipeg for two days and gave two lectures at this center Several reports have been submitted from New York, also from Canada and Minneapolis

My greatest difficulty has been to get the medical world to understand that the treatment evolved by me is not for symptoms previously recognized, but for a different concept altogether If the old concept was correct, then the old treatment would be the only logical treatment—although far from satisfactory For instance, in the year 1937 it was stated that it was most difficult—in fact it was impossible—to prevent spinal deformities, and the results achieved even in the most competent hands were often disappointing Dr McCarroll of St Louis admits that spinal deformities had occurred in the patients under review even while they were receiving treatment by the orthodox procedures In the Proceedings of the Staff Meetings of the Mayo Clinic (volume 17, number 29, August 12, 1942), the Professor of Physical Therapy states, with

regard to the cases treated by the Kenny method at the City Hospital, Minneapolis

> "I have seen no spinal curvatures in any of the fifty-four cases which have been under the care of Dr Pohl at the Minneapolis General Hospital for the past two years This alone indicates a distinct improvement over the usual methods of treatment"

Dr Schwartz of Rochester, New York, has made scientific research with regard to the condition of muscle spasm, and the results have proved my concept correct, and also my method of treating this damaging symptom the most effective This has also been upheld by the investigation of Dr Herman Kabat, University of Minnesota

The symptom or condition of the second symptom, alienation, the treatment for which is described in the following pages has also been well established by the much more satisfactory results achieved when this condition has been treated For instance, Dr A E Deacon in the *Canadian Public Health Journal* states

> "We were astounded to see Miss Kenny cause patients to use flaccid muscles which we had observed to be totally paralyzed merely by restoring *the patient's mental awareness* of the muscles, and thus correcting their alienation"

Unfortunately, when I would make a similar statement it was thought that I was a little unbalanced However, I could not cla[illegible] was [illegible]
restoring paralyzed mu[illegible] [illegible]
paralyzed [illegible] to func[illegible]
space of [illegible] four [illegible] in [illegible]
the orth[illegible] w[illegible]

muscles were completely paralyzed and the anterior horn cells destroyed However, these apparently flaccid muscles were normal muscles and had lost the power to contract owing to the brake put upon their action by the shortened, opposing muscle which had been in spasm If the anterior horn cells were destroyed, they would have remained useless, despite the relaxation of the muscles in spasm

I have frequently heard orthopedic surgeons remark that they have lengthened the tendo achilles on patients and put the foot at right angles in a cast and to their great surprise they have found upon removal of the cast that the anterior muscles have been found to function This phenomenon has happened as long as fifteen years after the onset and has been used greatly as an argument in favor of splinting Again I would maintain that if the anterior horn cells were destroyed and remained so for fifteen years an operation on the posterior leg would not restore them, but a treatment for the posterior leg muscles fifteen years earlier would have prevented the necessity for the operation and would have meant much to the patient

When the true symptoms of the disease are treated even imperfectly, the ultimate results are much more satisfactory, and when the treatment is given by a well trained technician the results are to most people amazing The control cases supervised by the department of orthopedic surgery, New York Orthopaedic Hospital, show gratifying results although the Kenny technique was poorly administered, and the orthodox procedures given by technicians who were very well trained in the orthodox method According to this statement, residual paralysis was reduced from 87 per

cent (orthodox) to 33 per cent (Kenny), deformities from 75 per cent (orthodox), 20 per cent (orthodox plus Kenny) to 8 per cent (Kenny) The functional results recorded by Dr Robert Bingham in the control series mentioned above from the Orthopaedic Hospital and Dispensary, New York, are both interesting and arresting

FUNCTIONAL RESULT

	ORTHODOX TREATMENT 12 PATIENTS	ORTHODOX PLUS KENNY 24 PATIENTS	KENNY TREATMENT 24 PATIENTS
Excellent	1	6	11
Good	3	8	10
Fair	4	7	3
Poor	4	3	0

Comment upon this evidence, which was submitted, not by myself, but by medical men, is unnecessary The report of Drs McCarroll and Crego support the statement that with the orthodox procedures the average percentage of recoveries was 12 per cent, even when carried out under the best possible circumstances

Considering the evidence produced herewith, the contents of this book are of national importance, there fore, the thanks of the nation should be extended to Drs Wallace Cole, Miland Knapp, and John F Pohl for their painstaking investigation and to those who came to listen and learn and write back such statements as the following

> "You have found symptoms and visible findings in this disease infantile paralysis that we had no idea existed You have demonstrated to me a disease I did not know existed"
>
> —DR HERBERT HIPPS, Orthopedic Surgeon, Torbett Clinic and Hospital, Marlin Texas

It is a treatment for these symptoms and visible findings that are explained in this work from the day of the onset to the day of maximum recovery Dr Krusen (Mayo Clinic) writes

> "Her ideas are original and she should be given full credit for having developed a new and extremely interesting concept of early poliomyelitis and the proper management of these symptoms

The concept has been accepted by the American Medical Association and the National Foundation for Infantile Paralysis Statistics prove that a new hope has dawned for the unfortunate sufferers from this disease Deformities are practically abolished and a much higher percentage of recoveries is obtained than by any previous method Therefore humanely and economically, the value of the gift cannot be estimated

The clinical investigation of this work was made possible by the Board of Public Welfare of the City of Minneapolis who unhesitatingly placed at my service facilities in the City Hospital in order that the staff might proceed immediately with the work and thus expedite its evaluation The efforts of the Board with regard to this matter have been very much appreciated by me The noble building established by the Board of Public Welfare in the City of Minneapolis, known as the Elizabeth Kenny Institute will I hope, provide a further means of distributing this work throughout the world

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INTRODUCTION

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TRADITION has regarded infantile paralysis as a disease whose main characteristic was that the connection between the muscles and the central nervous system was interrupted and tended to disappear No more was known than that Certain muscles were caused to be weakened or paralyzed but this was quite understandable when it was shown that the large motor nerve cells of the anterior horns in the spinal cord suffered injury and actual destruction from the effects of the disease The loss of power in muscle was the only symptom to which any serious attention was attached The explanation of the entire behavior of the disturbed musculature was unfortunately based upon an interpretation of these observed anatomical changes in the spinal cord Quite unexplored was the possibility that the disease might cause purely functional derangements in the nervous conducting mechanism and that loss of control of muscle could be due to disorganization and disruption of the nerve cell connections and synaptic relationships which might persist in spite of the survival or recovery of the cells themselves

The only pathway over which the motivating nerve impulses may be conducted to muscle arises in the

spinal cord from these motor cells of the anterior horn It seemed logical and sufficient reasoning that a dis ease process capable of destroying these cells would cause structural and irrevocable interruption of the conducting mechanism at the site of the lesion

The orthodox conception of the disease, based on these purely anatomical considerations could be sum marized as follows

1 The affected muscles were hypotonic and flaccid They hung loosely like a hammock be tween their points of attachment
2 Loss of ability to contract a muscle indicated *destruction of the motor cells for that muscle* in the spinal cord
3 *The patient retained the power to contract* all intact motor units
4 Any resumption of contractility of paralyzed muscles was entirely spontaneous and indi cated recovery of injured spinal cord cells
5 The non affected muscles contracted involun tarily, the resulting shortening causing stretch ing of the weakened supposedly affected opponent
6 Deformities were the result of disturbed mus cular strength, the strong normal muscle out pulling the weakened opponent
7 Incoordination was not a feature of the dis ease
8 Stiffness was not explainable

There was every reason for the conventional attitude of pessimism toward the paralysis resulting from nerve cell destruction since it is known that nerve cells do not regenerate It is impossible by any known means to revivify dead nerve cells and restore the vital conduc tion paths of which they and their projections form an

indispensable part Treatment of the disturbed mus culature based on the conception of nerve cell paralysis could be summarized as follows

1 *Immobilization* (splinting by use of wire frames or plaster casts) —The object of the procedure was

(a) to rest the weakened muscles
(b) to suppress neurological activity at the site of the lesion in the spinal cord
(c) to prevent deformities

2 *Re-education* —As injured nerve cells in the spi nal cord recovered, the muscle fibers which they served to innervate would gradually and spontaneously resume function Re education was really based on the sup position that graduated muscular exercise would strengthen the surviving intact motor units

Even the most sanguine advocate of the above principles of treatment will admit that they fell far short of their object Deformities too frequently occurred to deny that immobilization was ineffective in preventing this most unfortunate sequela In fact, even casual inspection of the patient acutely ill with infantile paralysis is sufficient not only to raise serious question concerning the entire previous conception of the disease but to suggest that the treatment whose principles are stated above would prove more harmful to the patient than helpful

Splinting denied the existence of any condition affecting the muscle tissue proper because it prevented treatment of the muscles Splinting encouraged atrophy and shortening of muscle which are in themselves very damaging to the action of these structures Splinting defeated the aim of re education because

immobilization has for its purpose the dissociation of muscle from the nervous system and physical dissociation *promotes mental dissociation* Re education as ordinarily practiced and especially under water encouraged substitution of muscles a process leading to a very disturbing state of incoordination

Critical examination of infantile paralysis in the acute stage *will present abundant evidence to show that* orthodoxy has erred both in the recognition as well as in the interpretation of the physical findings in the disease

Consider for instance the common symptom of pain in muscle Pain associated with tenderness usually heralds the coming of paralysis in the muscle involved In the condition of direct foot drop the anterior tibial muscle is supposedly paralyzed but experience shows this muscle almost never to exhibit pain or tenderness with the failure of function This muscle which orthodoxy has considered paralyzed and for which rest in a splint has been advocated is a normal muscle *The anterior tibial has become divorced or alienated* from the nervous system The cause of its loss of function will be found in its opponent the gastrocnemius which will exhibit pain hyperirritability and spasm The anterior tibial muscle can be encouraged to resume function only when the condition of spasm and shortening in the affected muscle the gastrocnemius in this case has been released The affected muscles in spasm *do not recover spontaneously* but rather if untreated lead to fixed shortening and contractures with the result that stiffness and permanent deformities are established The painful muscles in spasm are naturally protected by the sensitive nervous

system, being subjected neither to stretching nor to contraction, therefore nerve impulses to the region are so directed as to avoid pain The result is that abnormal patterns of motor activity are liable to be set up and a permanent state of incoordination established in the improperly treated case Orthodoxy has largely been devoted to treating normal muscles and has failed to recognize the true condition in the muscles affected by the disease

This then is the real contribution of Miss Kenny, not a new treatment for the disease of infantile paralysis as it has been conceived in the past but a conception of the disease itself so radically opposed to the old as to almost warrant considering the entity as a new disease The basic principles of the disease built upon the observations of the behavior of the musculature following an attack of the disease may be stated as follows

1 The affected muscles are painful, hyperirritable and in spasm
2 The flaccid muscles are normal Loss of ability to contract these is due to functional dissociation (alienation) from the nervous system
3 Ability to voluntarily contract the non functioning muscles returns only after releasing spasm in the opponents and carefully restoring the physiological continuity of the nerve conduction paths back to the muscles
4 Paralysis due to nerve cell death occurs but is not a common condition Most supposed weakness is due to untreated spasm and to disuse in the dissociated muscles
5 Incoordination of muscle action appears in the untreated case
6 Deformities do not occur Those resulting

from the old methods were due to untreated muscle spasm

In short Miss Kenny's discovery is that infantile paralysis is a disease in which disturbance of physiological function of the nervous system is of more importance than actual architectural change Many of the observable clinical phenomena are the result of functional disorganization of the motor centers and of the nerve pathways to the muscles The disease affects muscle as well as nerve tissue Muscle spasm is the primary lesion in the disease rather than paralysis Miss Kenny has designed a treatment for these conditions Needless to say the treatment could have nothing in common with the previous methods designed for a disease of opposite conception

PART I

THE ACUTE STAGE

INFANTILE PARALYSIS

Definition and Symptoms of the Disease in the Acute Stage

INFANTILE paralysis is an acute infectious disease caused by a filterable virus in which the invading agent or its product attacks and produces varying degrees of injury, disorganization and disintegration of the neuromuscular system manifested clinically in the acute stage by

1 *Muscle Spasm*
2 *Mental Alienation of Muscle* (Nerve muscle dissociation)
3 *Incoordination of Muscle Action*
4 *Muscle Weakness and Paralysis*

Muscle Spasm, the universal symptom of acute infantile paralysis is the earliest and most important single objective finding in the disease This is a hypertonic condition affecting the muscles marked by persistent involuntary contraction of the muscles affected present in every case where the diagnosis is definitely established It is usually associated with pain tenderness and hyperirritability of the involved muscle Such muscles being maintained in hypertonic contraction are unable to relax or lengthen and tend to remain in a persistent state of shortening if untreated

Mental Alienation of muscle, or pseudoparalysis is a condition appearing most commonly in the muscles opposed to those in spasm Alienated muscles appear toneless and incapable of voluntary contraction but are never painful or tender, indicating that they are not the muscles involved directly by the disease Such muscles become divorced or dissociated from the motor centers presumably by some physiological block in the continuity of the nervous pathway Effective early treatment will restore alienated muscles to useful function

Incoordination of muscle action is a condition frequently associated with muscle spasm and mental alienation but represents a disorganization of the regulating motor centers of the nervous system The resulting misdirection of nerve impulses considerably disturbs the smooth rhythmic action of muscles in producing orderly and effective joint motions in the region involved Incoordination becomes permanent and seriously adds to the patient s disability unless proper steps are instituted early in the disease to combat the condition

Muscle Paralysis, or partial paralysis represents a loss of power in all or part of the fibers of a muscle and is presumably a result of the injury or destruction of the anterior horn motor cells of the spinal cord supplying those muscle fibers This condition would represent an organic or structural interruption of the nervous pathway from the motor centers to the muscle Such muscles may recover to some degree depending upon the severity of damage to the anterior horn cells Actual paralysis or complete motor denervation of muscles however, is not a common feature of the disease

For convenience of discussion the course of the disease may be divided into three stages

1 *The acute stage* dates from the onset of the disease through the presence of the acute symptoms

   Besides the general constitutional manifestations such as fever, headache, vomiting apprehension and irritability, the specific neuromuscular symptoms mentioned above are to be found Noteworthy is the presence of painful acute muscle spasm which may be of extreme degree and particularly disturbing to the patient It is of great importance that treatment for muscle spasm be promptly instituted as soon as the diagnosis is established in order to make the patient more comfortable as well as to minimize the damaging effect of the spasm Careful attempts at the preservation of awareness of non functioning or alienated muscles may be started in some cases but due to the fact that many muscles may be in a hyperirritable state with spasm and that incoordinate muscle actions may appear, voluntary efforts on the part of the patient are definitely to be discouraged Under proper treatment the acute stage may be considered to last usually from twelve to fourteen days and is terminated by the relief of painful acute spasm

2 *The convalescent stage* dates from the cessation of acute muscle spasm to the time of maximum recovery of the patient

   Measures begun in the acute stage for the restoration of the function of the neuromuscular system will be continued and all other treatment with this purpose will be instituted and exploited in great detail These measures

are designed to combat the symptoms mentioned in the opening paragraph, namely, to relieve muscle spasm and the ensuing state of contraction, to restore awareness and function to alienated muscles, and to combat substitution and incoordination of muscle action The convalescent stage varies in length according to the severity of the attack in the individual case but is usually considered to terminate at the end of two years This is the time during which recovery of damaged anterior horn cells is considered to have been completed and recovery of muscle weakness from this cause to have reached a maximum

3 *The chronic stage* is reached when the damaged neuromuscular system will be considered to have attained a stationary level and maximum recovery by treating the symptoms to have been effected

A small number of these patients will need artificial supports but practically all will be able to walk There is often improvement in functional performance over a period of years Surgery will aid in the rehabilitation of selected cases

THE CLINICAL SYNDROME

Infantile paralysis is a disease which varies in the intensity of its attack All cases show muscle spasm and practically all will exhibit incoordination but not necessarily alienation or muscle weakness Only the most severe cases will present the clinical neuromuscular syndrome in its entirety From careful study in the acute stage, it is evident that the disease is one which is capable not only of causing weakness but of wide

spread disturbance of the normal musculo mechanical action of the body Most noteworthy is the knowledge that the major portion of the nervous system seems implicated and that purely functional disturbances of physiological activity commonly occur It has long been known that in severe cases of the disease there would be actual destruction of the motor cells of the anterior horn of the spinal cord with resulting paralysis of the corresponding muscle fibers True paralysis or muscle weakness is not the most common feature of the disease and *is in itself not nearly as disabling as other neuro-*muscular disturbances which are commonly present The emphasis which has been placed upon the anterior horn cell and the apparent paralysis of muscle has tended in the past to obscure the possibility that other and probably equally as disturbing phenomena might occur in the disease Examination of the acute case brings strikingly to attention that the patient suffers from something more than mere weakness of muscle The affected muscles are tender, painful, irritable and in spasm, and temporary deformities are present due to the pull of shortening muscles

To follow the untreated patient through convalescence is to see temporary distortions become fixed deformities in spite of the bed rest and protection of the old conventional methods of treatment Even in the non paralytic case treated by these orthodox measures, curvature of the spine was known to occur and to progress notwithstanding strenuous preventive and corrective measures Tightened hamstrings, stiffness and other abnormal muscle conditions were found years after apparent recovery from an attack of infantile paralysis

In fact, not only had the real symptoms of the dis ease of infantile paralysis been overlooked but had actually been stated by reliable medical authorities not to occur Furthermore, many of the muscles which had been pointed out as being flaccid and perhaps paralyzed are in reality the normal non affected muscles These are the *alienated muscles* They had been rendered non functioning by previously unrecog nized aspects of the disease Treatment had therefore been directed into the wrong channels and for condi tions which did not exist

1 *The Nature of Muscle Spasm and its Effect upon the Neuromuscular System*—Spasm is a condition af fecting muscle, appearing at the onset of clinical symp toms of the disease of infantile paralysis manifested by hypertonicity, pain and hyperirritability of the involved muscles It is the earliest objective symptom of the disease as evidenced by the common complaint of pain and stiffness of the neck It is present in the mild so called *abortive* and *non paralytic types of cases* Spasm may affect any of the skeletal muscles of the body The condition is present in every case of infantile paralysis While it predominantly appears in the pos terior muscles of the body especially the neck, spine hamstrings and gastrocnemii, it may and frequently does attack the anterior muscles, particularly the inter costals, pectorals, biceps brachii abdominals and quadriceps Spasm may appear in single muscles but is *more apt to affect a group of muscles associated with* a joint motion or action of the body Spasm is an in voluntary tendency on the part of the muscle to con tract and shorten itself The condition is very often

associated with pain and tenderness of muscle, and the muscle is hyperirritable to stretch To relieve the pain and muscle tension, the patient assumes various attitudes which allow the muscle to shorten, and it is usually unnecessary to examine the patient in detail to determine the presence of spasm The patient flexes the hip upon the body where spasm is present in the hip flexors The arm is frequently held flexed at the elbow where spasm is present in the biceps brachii The head is often held in retraction where spasm is active in the posterior neck muscles The patient may be forced into exaggerated lordosis or even opisthotonus by spasm of the posterior spinal muscles Many other instances might be mentioned but the examples given serve to emphasize the fact that spasm is the condition affecting the muscles in infantile paralysis

The origin or cause of muscle spasm in infantile paralysis is not at this time known Spasm with pain is a symptom appearing early and may be the only symptom in the milder cases In the more severe attack, paralysis follows spasm but in this case the spasm is the prelude to oncoming paralysis in the muscle affected From this standpoint, the most logical theory for the origin would lie in the supposition that spasm is merely evidence of hypertonicity or increased tonic innervation due to irritation of the motor cells of the cord and that paralysis will follow if these nerve cells are sufficiently injured or destroyed Unfortunately for this theory as a single explanation, spasm or shortening usually persists even in those muscles which become permanently paralyzed with apparent complete destruction of the corresponding motor nerve cells in the

spinal cord This has been observed where paralysis is exhibited within a day or two of the onset of symptoms of the disease, but in the exceptional case where fulminating paralysis appears very early and is widespread the stage of spasm may be fleeting and be undetected Mere hypertonicity of muscle is insufficient to explain the series of destructive events which appear in the affected muscles in untreated infantile paralysis

Muscle spasm is frequently observed in other disorders of the neuromuscular or skeletal systems of the body but the spasm of infantile paralysis is not similar *in behavior Usually spasm of muscle in other disorders* is relieved by removing the underlying cause responsible for the reaction in muscle, leaving the muscle tissue itself quite normal, and only if the muscle has been in spasm for a long period of time is even adaptive shortening apt to be permanent

The muscle spasm of infantile paralysis does not completely relax under deep general anesthesia If untreated it can destroy muscle tissue Therefore, while it seems logical to assume that spasm may be initiated in the central nervous system because it anticipates paralysis, the conclusion that some concomitant process is taking place in the muscle itself seems unavoidable This may be primarily a direct attack on the muscle by the virus or its product at the myoneural junction or through the bloodstream but whatever *the mode, the end result, if spasm goes* untreated, is frequently a serious modification in the muscle substance A secondary consideration is that of altered or diminished blood flow through a muscle in spasm causing an ischemia or anoxia

Definition and Symptoms in the Acute Stage

In the acute stage the affected muscle is painful and tender and has almost the attributes of an acute inflammatory condition Untreated spasm destroys the delicate muscle tissue, causing atrophy, fibrosis, eventual loss of power and permanent contractures The late effects of untreated spasm resemble in some respects the ischemia of arterial occlusion The fact that spasm is relieved by moist heat only by treating the specific area of involvement would tend to bear out the contention that a local process is taking place in the muscle

Under treatment, the stage of acute painful spasm in muscle will usually subside within two weeks Some tendency for the muscle to remain in a shortened condition or contraction, especially if treatment has been delayed, may persist for weeks or months It is worthwhile for the sake of clarity to define the terms of spasm contraction and contracture, muscle conditions related to each other *Spasm* is the painful hypertonic affection of muscle present in the acute stage of infantile paralysis and is distinguished by exaggerated tonus or hyperirritability of the muscle to stretch A muscle in *contraction* following spasm is temporarily shortened and may be slightly painful to stretch but is without exaggerated tonus Such muscle in hypertonic contraction will eventually assume full length with adequate treatment A *contracture* is the end result of untreated spasm and indicates that the muscle is permanently shortened Fibrosis and actual shortening of muscle tissue has occurred Such muscles may still be somewhat painful to forceful stretching but there is no evidence of hypertonicity

The Effect of Spasm upon the Muscle Involved—Spasm if untreated has *serious effects upon the future* action of the muscle involved as well as upon the associated structures

(a) Untreated spasm by destroying muscle tissue causes atrophy and loss of strength in the muscle because of *reduction in the number* of contractile elements If allowed to continue the final result is frequently a fibrous inextensible non elastic mass This is especially apt to be the result when spasm appears simultaneously in muscles opposed to each other in action

(b) Muscle depends for its function upon an ability to lengthen and shorten itself Normally *in contracting a muscle is able to* exert its maximum force starting from the position of full extension The effect of spasm *is to shorten a muscle and the result of* this process if allowed to develop is to lessen the ability of the affected muscle to give a forceful contraction because part of its potential action has been taken up by the shortening

(c) Frequently such shortened muscle is noted to *have lost the smooth graduated rhythm of* its action and appears to function as a single unit when attempting contraction In other instances *there is fasciculation and tremor* on effort The coordination of the individual units within the muscle is disturbed and consequently *the action* of the muscle is less effective

(d) Spasm if untreated causes permanent shortening of muscle *fibrosis and eventual contracture* These fibrous structures pull upon the articulated skeleton and cause deformi

ties Shortened limbs often result because of the mechanical action of these fibrous tissues in not allowing the skeleton to grow in length

(e) Stiffness is entirely a result of shortened muscles due to untreated spasm The limitation of joint motion restricts the patient's activities and disables him, although he would not appear to have deformities in the strict sense of the word

In addition to the effects just mentioned, muscle spasm is associated with, and is in part responsible for, changes in the behavior of the other muscles in the region affected Alienation frequently appears in the opponent of the muscle in spasm, and coordination of the action of adjacent muscles is apt to be disturbed

2 *Mental Alienation of Muscle* —The disease of infantile paralysis is apt to disturb the normal physiological activity of the nervous system and cause purely functional disorders to appear Muscles opposed to those in spasm frequently cease functioning, drop from the patient's consciousness and become alienated or divorced from voluntary action These are the muscles which were formerly thought to be the flaccid paralyzed muscles characteristic of the anterior horn cell destruction of the disease Such muscles are never painful or tender Alienated muscles are examples of the effect of a physiological block in the motor pathway. They have merely ceased to function and become temporarily dissociated from the nervous system by the action of the disease and in some instances as a direct result of the effect of spasm of the opposing muscles Even the tendon reflexes of such muscles disappear and the alienated muscle has the appearance of having

been paralyzed Alienated muscles do become permanently paralyzed and atrophied if steps are not taken early to restore such muscles to action An alienated muscle is usually recognized by the fact that its opponent is in spasm and tending to shorten

It is obvious that splinting in a position of rest could not be the treatment for the alienated, non functioning muscles To do so would only serve to put tension upon and to further irritate the opponent in spasm which is really the affected muscle It is possible, however, that a non functioning muscle is actually paralyzed, but in this case the majority of the muscles in the region including those opposed to each other, will prove to have been rendered permanently inactive by the destructive effect of the virus upon the anterior horn cells of the spinal cord The alienated muscle can usually be distinguished from the paralyzed muscle by the fact that the alienated muscle may be made to exhibit a slight amount of tonus Stimulating such muscle by flexing the appropriate joint several times will frequently cause the tendon of the muscle to become visible by virtue of the tonus excited in the muscle tissue The truly paralyzed muscle fails to exhibit this objective finding

The exact mechanism of the process of alienation is not clear It is possible that all non functioning muscles are rendered so by the action of the virus upon the corresponding spinal anterior horn cells or upon the motor tracts The fact that the alienated muscle is so invariably the one opposed to the muscle in spasm would seem to indicate that the two conditions are related to each other in origin or in the effect of one upon the other There is probably no single cause

for the condition of alienation of muscle, but at least four mechanisms offer possible explanation

(a) *Reflex pain inhibition of muscle action* — In any explanation of alienation of muscle the factor of pain must be kept in mind because of the possible reflex effect upon the action of muscle Pain may be an important factor in causing alienation Nature protects the painful structure, in this disease the muscle in spasm, by inhibiting the action of all adjacent muscles which might, by contraction, increase the pain in the muscle in spasm Consider the leg for example, the gastrocnemius in spasm causes a direct foot drop If the gastrocnemius is painful the anterior tibial will certainly make no response to voluntary effort because to contract the anterior tibial is to stretch the gastrocnemius and increase the pain The anterior tibial is therefore dissociated from the motor centers and becomes alienated

(b) *Stretching of the alienated muscle* —Certain muscles normally contract from an established resting length Persistent elongation of the muscle beyond this resting length, due to spasm in the opponent, interferes with the ability of the muscle to respond to stimuli and such muscles may eventually be abandoned from the motor pattern An example is the tibialis anterior muscle which may be placed in a position of continuous stretch by unreleased spasm of its opponent, the gastrocnemius, in the condition of direct foot drop

(c) *Braking effect of the muscle in spasm* — Failure to relieve spasm, with the resulting

persistence of muscle shortening, restrains the action of the opposing alienated muscles The shortened muscle serves as a brake upon its alienated opponent and so mechanically interferes with function that voluntary efforts at contraction are further seriously discouraged

(d) *Reciprocal innervation of muscle*—This theory depends upon the hypothesis that spasm is the result of a continuous discharge of contraction producing impulses issuing from the anterior horn cells of the spinal cord According to the law of reciprocal innervation of muscles, the opposing muscle to the one in sudden spasm would not only fail to receive impulses for contraction but would, in fact, receive impulses for the opposite action, extension The motor path to the non-functioning muscle is thus interrupted temporarily and is known to remain so unless steps are taken to restore this contact and the physiological continuity of the brain pathway

From the foregoing discussion it is apparent that there are logical and acceptable explanations for the conclusion that alienation of muscle is a functional process based upon disturbance of the physiological continuity of the motor tracts between the conscious voluntary brain and the muscle While it is conceivable that the virus is able to set up such a block by direct action upon the motor paths or upon the anterior horn cells of the cord, one would expect such interruption to be temporary and the corresponding muscles to resume function spontaneously as the disease process in the spinal cord subsides On the contrary, the alienated

muscle fails to resume function and undergoes progressive atrophy much like true paralysis unless the spasm in the opponent is treated and prompt steps taken to restore awareness of the alienated muscle in the patient s consciousness The condition of alienation of muscle if unrecognized will thus materially add to the disability of the patient in his final recovery The proper treatment for restoration of such muscles will be described in appropriate chapters dealing with the neuromuscular system

3 *Incoordination* —The third finding in the disease of infantile paralysis which causes disorganization of the neuromuscular system is that of incoordination of muscle action This is a condition arising in the central nervous system in which the regulation and direction of nerve impulses is upset so that the natural rhythmic and cooperative action of associated muscles is disturbed The muscles concerned are otherwise normal and retain full power of contraction but the misdirection of nerve impulses makes muscular activity incoordinate and ineffective The condition may be expressed clinically in different ways yet in any case the definition implies that the process is in no way concerned with the volition or will of the patient but rather is a disorganization of the regulating centers and nerve pathways directly attributable to the disease process itself Undoubtedly the presence of pain and spasm in certain muscles tends to encourage the establishment of incoordination nevertheless the condition if untreated persists after the release of spasm and hence must be considered to be a disturbance of the nervous system proper probably of the sensory

motor arcs at *the site of the lesion* Practically every untreated case, including the mild or non paralytic, *will* show evidence of the symptom of incoordination, and the condition will persist after the supposed recovery of the patient Examination of such patients frequently shows opposing muscles attempting to contract together to produce a given motion with the result that the motion is *poorly performed* *In other instances*, there can be noticed an involuntary action of muscle quite unrelated to the motion solicited by the examiner For example, the hamstrings frequently contract when the patient is requested to plantar flex the foot although the calf muscles themselves will be found to be strong and perfectly adequate to perform the motion Muscular activity in the untreated case is spasmodic and poorly controlled and the patient lacks rhythm in his *motions because of the misdirection and confusion of* nerve impulses

Incoordination is not to be confused with substitution of muscle, a condition under the control of the will of the patient in which he attempts to replace a weak or paralyzed muscle with one which is stronger Substitution must also be prevented because it will encourage *the establishment of incoordination in the* muscles of the region More than that it will prevent the recovery of the weak or non functioning muscle by directing the impulses to the muscle being substituted and hence makes the condition of alienation permanent The condition can best be illustrated by considering the shoulder joint as a typical example If for any *cause the deltoid* is unable to abduct the extremity the patient will attempt to simulate abduction by substituting *the trapezius, elevating the shoulder* and rotat

ing the scapula Movement of the arm away from the body then depends upon the fixation of the humerus in the glenoid cavity of the scapula The fixation is often done by the pectoralis major the adductor of the shoulder which should never contract for normal abduction It is obvious that to allow or encourage the patient in this action is to remove the possibility of ever restoring function to the deltoid or the correct muscle action to the part Every muscle action must be correctly restored to the motor center by careful re education if proper rhythmic action is to ensue

The condition of incoordination can be prevented if the case is treated in the early stage of the disease The method of dealing with the problems of incoordination and substitution will be taken up in the appropriate chapters dealing with the neuromuscular system

4 *Muscle Paralysis* —The virus of infantile paralysis once having gained access to a susceptible host appears to have an affinity for nervous tissue All parts of the nervous system have shown evidence of attack by the disease but the spinal cord has received the most at tention from medical investigators because of the ob servable effect of damage to the cellular structures of the cord The injury and possible complete destruction of the anterior horn motor cells is considered clinically evident by loss of function in the muscles supplied by those nerve cells This may be a tran sient condition the muscle recovering function as the inflammatory process in the cord subsides In the most severe instances where there is actual damage and destruction of the anterior horn cells there will result permanent and irreversible loss of contractibility

in the muscle tissue supplied by the corresponding motor cells This represents an organic or physical block in the motor pathway for which there is no known therapy The circumstances of injury and recovery of *the anterior horn cell appears to be purely* a matter of chance for there is no known means of modifying the attack of the virus upon the nervous system

Some recovery of the injured motor cells is usually expected in most cases of infantile paralysis as the inflammatory process in the cord subsides This is clinically evident by resumption of contractile function in the corresponding muscles as nerve pathways are restored Recovery of injured anterior horn cells may take place over a long period of time Ultimate function *of the muscle will be dependent to a very great* degree upon the state of the muscle tissue when nerve impulses are again delivered to the muscle The nervous system after all merely serves to deliver impulses to the muscles in order that mobility may occur Muscles which have been allowed or encouraged to become shortened or to have become atrophied fibrosed and inelastic through the process of spasm will have very little usefulness even though recovery of the anterior horn cells is complete The relationship of spasm to *the condition affecting the spinal cord* structures has been mentioned

Most logically spasm of muscle would appear to occur as a result of some irritating process involving the motor cells of the cord and would represent merely a preceding symptom to the paralysis which would follow if the motor cells were sufficiently damaged The fact that spasm and shortening of the *muscle per*

sists even after complete destruction of the motor cells in infantile paralysis suggests that there is a *concomitant direct attack upon the muscle tissue by* the virus or its product There is always the possibility that anterior horn cells are only temporarily disabled and will resume function Treatment designed toward relieving spasm, preventing shortening and contractures, keeping the muscle tissue in a state of health and good nutrition and receptive to nerve stimuli will reduce paralysis and will be of great importance in the resumption of useful muscle function when the nervous system has recovered from the disease

Summary

Infantile paralysis is neither a simple disease nor one completely understood The destruction of anterior horn cells of the spinal cord is certainly not the principal nor most important characteristic and does not explain the presenting symptoms of the disorder From the discussion presented, infantile paralysis affects both muscle and nerve tissue and is a disease capable of widespread disorganization of the neuromuscular system The condition of muscle spasm is the symptom common to all cases Untreated spasm destroys muscle tissue and is the cause of contractures, stiffness and deformities In addition, the patho physiological symptoms of mental alienation of muscle and incoordination of muscle action implicate the more highly organized portions of the nervous system Paralysis is unfortunately a feature of the disease but paralysis proves after all to be a minor consideration in most cases of infantile paralysis Muscle spasm, mental alienation

and incoordination are far more damaging to the bodily mechanics Acceptance of these true symptoms forms the real basis on which the disease can be studied and an effective treatment for the disease can be designed Only meticulous attention to all of the disturbed structure can reduce the evil after effects of the disease

CLINICAL CONDITION

*Examination of the Patient Detection of Spasm
Analysis of Neuromuscular Conditions*

INFANTILE PARALYSIS is a disease whose main characteristic in the acute stage is that the affected muscles are in a state of spasm The condition appears early, in association with the symptoms of general systemic infection such as fever headache vomiting, restlessness and irritability Stiff neck, commonly mentioned as a diagnostic symptom of the disease, is a characteristic example of the muscle condition Certain of the other skeletal muscles are always affected by the same disturbance and in some cases most of the muscles of the body are involved Patients exhibiting respiratory distress are usually suffering from the effects of spasm of the respiratory muscles Even in the bulbar case, where the virus directly attacks the vital centers, the muscle spasm commonly present in the region of the head, neck and thorax contributes to the distress and may be the factor determining the survival of the patient Spasm is a condition largely responsible for the apparent loss of power in muscles and also, if untreated, will result in permanent muscle damage, stiffness and skeletal deformities Since an appreciation of its presence, immediately that the dis

ease is diagnosed, is necessary in order that prompt steps can be taken to insure recovery of the disturbed musculature, it is very important that the means of detecting the presence of muscle spasm be understood

The condition of muscle spasm in the acute stage of infantile paralysis appears almost to have the properties of an acute inflammatory process capable of causing serious and permanent changes in the muscle substance It is therefore necessary to observe the greatest possible respect for this tissue in order not to increase the damage In short, the examination of the patient should not include stretching, squeezing or manipulation of the affected muscles nor should the patient be requested to make any voluntary efforts at contraction of muscle

It is recognized that certain muscles, noticeably the opponents of the muscles in spasm, have become non functioning This is of no immediate concern since *these non-functioning muscles usually are simply alienated* Such muscles, however, cannot be restored except by first treating the condition of spasm in the opponent Attempts to determine the presence or absence of contractile power in muscle are therefore not only impossible and of no value, but they have the serious effect of increasing the spasm in the affected muscles *Under no circumstance should the acutely ill* patient be encouraged to contract any of his muscles for the purpose of recording the so called muscle test

Spasm manifests its presence in ways which are easily noted without detailed examination Inspection or observation alone usually suffices for the purpose of analysis of the muscle condition Listed below

are the most common indications of the presence of spasm

1. *Pain* —Muscles in spasm are frequently painful, especially if the spasm is severe Pain is an infallible guide to spasm and the appearance of pain demands that the area be inspected and attended for the condition of muscle spasm
2. *Increase in the Plastic Tone of the Muscle* —This is really an early finding, occasionally detected preceding the appearance of true hypertonic spasm The examiner, on lengthening the muscle by putting the joint through a range of motion, is aware of a feeling of resistance similar to that of stretching India rubber Power is still present, and the muscle is not painful, but the finding of this peculiar rubbery sensation indicates that spasm will appear and that the muscle will probably become paralyzed
3. *Involuntary Shortening of the Affected Muscle* —This is characteristic of all muscles in spasm The effect of shortening of the muscle is to limit the normal range of motion of the joint However, the shortening process also causes the following visible changes which are practically as reliable and should be depended upon because they eliminate the necessity of disturbing the sick patient
   - (a) The tendon of the affected muscle may be caused to stand out more prominently because of increased tone of the muscle
   - (b) The skin folds over the affected muscles or their tendons are abnormal in appearance The skin creases tend to be less marked in some cases and the grooves to be exaggerated in others
   - (c) The muscle belly is changed in contour,

being more prominent early, but with a tendency to flatten and become narrow with the persistence of spasm

(d) Disturbance in bodily alignment The patient is caused to assume varying abnormal postures due to the mechanical pull of the shortened muscle upon the articulated skeleton In some cases the patient voluntarily adapts his lying posture to the position of comfort by relieving tension in the painful muscles

Persistent disalignment of the body or a part gives us the most useful clue as to the presence of spasm While individual muscles frequently go into spasm alone, in most cases the group which is associated in the performance of a given motion are apt to be involved together The component parts of a group may not have the same degree of spasm Either head of the gastrocnemius muscle, for example, may have a greater degree of spasm than the other, and the resulting unequal pull will cause a distortion in the normal alignment of the heel The paired extensor muscles of the trunk frequently exhibit spasm on one side more than the other, and the resulting bowing of the spine toward the side of lesser spasm will become a permanent curvature unless proper steps are taken to relieve the condition of spasm Other deformities which were common to the orthodox method of treating the disease were the result of persistent unrelieved pull of the shortened muscles upon the skeleton by unobserved and untreated muscles in spasm in the acute stage of the disease Some of the more common examples of the condition will be mentioned

ANALYSIS OF MUSCLE CONDITIONS

Detection of Spasm by Observation of Disturbed Bodily Alignment

Head Held in Extension Stiff Neck.—This condition is caused by spasm of the posterior neck muscles and is usually present in every case In some instances, the spasm is so severe as to cause actual retraction of the head, a position which seriously interferes with breathing and swallowing It will be found that the sulcus or groove from the base of the skull has become deepened (Figure 1) and that the muscles on either side are hard and contracted The supine patient is unable to raise his head because of the shortened posterior neck muscles When requested to do so it will be noticed that he attempts to use the chin The sternomastoid muscles may have become completely alienated and give no sign of contraction The platysma muscle substitutes but pulls the corners of the mouth downward while the forehead falls backward (Figure 2)

Head Held in Lateral Flexion.—Severe spasm of one side of the upper trapezius will cause the head to be flexed to that side if the scapula is fixed The affected muscle is easily palpated as a firm structure in the posterior lateral neck The sternomastoid of the opposite side is frequently caused to be alienated

Rotation of the Head.—This condition is caused by spasm of the sternomastoid muscle, which will be found to stand out prominently on the side *opposite to that to which the face is turned* These muscles, which are accessory muscles of respiration are frequently in spasm in conditions affecting the inspiration of air (See chapter on The Respiratory System)



Figure 1 Acute infantile paralysis Contracted upper trapezius and exaggerated sulcus Spasm of the posterior *neck muscles prevents forward flexion of the head*



Figure 2 *Attempt by the patient to raise his head when the posterior neck muscles are in spasm* The platysma contracts and pulls the corners of the mouth downward (Same patient as Figure 1)

Protrusion of the Mandible —Spasm of the rectus capitis posterior accompanied by spasm of the platysma would be evidenced by the head drawn backward and the chin downward This would give the patient an abnormal bite with protrusion of the mandible

Forward Cupping of the Shoulder —The pectoral muscles are responsible for this disturbing condition Spasm of the pectoralis major makes abduction of the shoulder painful or even impossible and the opposing deltoid muscle may as a result resign its power of contraction and appear paralyzed (Figure 28) The scapula is frequently pulled forward and rotated causing the rhomboids to be stretched and lose power Also the muscle fibres of the pectoralis are to an extent mingled with those of the intercostales and spasm of the pectoralis will interfere with the action of the respiratory muscles (*See chapter on* The Respiratory System)

Elevation of the Shoulder —The distance from the ear to the shoulder is shortened by spasm of the upper trapezius muscle The muscle can be palpated and is hard and contracted The scapula is caused to be elevated and rotated interfering with the action of the rhomboids and the latissimus dorsi

Spine Held in Extension —The posterior spinal muscles are almost always in spasm in acute infantile paralysis In some cases the condition is so severe as to force the patient into opisthotonus Persistent shortening of the posterior muscles prevents the patient from coming to a sitting position and frequently leads to a mistaken diagnosis of weakness of the abdominal muscles When the patient is sat up he assumes the tripod position (Figure 3) Unsymmetrical lordosis with one side more arched than the other is due to



Figure 3 Acute infantile paralysis Spasm of the posterior spinal muscles prevents forward flexion of the body Permanent lordosis will result if the muscles are not released



Figure 4 Acute infantile paralysis Effect of spasm of the right quadratus lumborum muscle If untreated, the patient will have a structural scoliosis

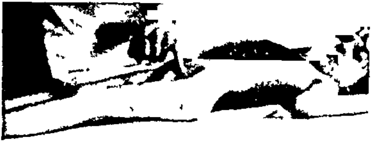


Figure 5 Acute infantile paralysis Spasm of the sartorius muscle causes the pelvis to drop or tip forward This will result in a permanent deformity unless the muscle condition is treated



Figure 6 *Acute infantile paralysis Spasm* of the iliopsoas muscles causes the pelvis to tip forward and the back to arch

spasm of the quadratus lumborum corresponding to the more arched side (Figure 4) Persistent lordosis due to shortening of the iliocostales lumborum will stretch the abdominal muscles beyond their normal resting length causing them to lose power and become alienated

Pelvic Drop or Forward Tipping—This condition is usually caused by spasm and shortening of the sartorius muscle which will be observed to stand out or be palpable as a tight structure just distal to the anterior superior spine of the pelvis (Figure 5) If the sartorius is not in spasm the position of forward tipping of the pelvis is probably due to spasm of the hip flexor muscles (Figure 6)

Pelvic Tilt Lateral or Upward—Abdominal muscle spasm occurring in infantile paralysis has frequently resulted in the mistaken diagnosis of acute appendicitis Bilateral spasm causes the pelvis to tip upward flattening the spine More often the spasm is unilateral causing the pelvis to be pulled upward on the affected side and to tilt to the opposite side An apparent leg shortening will appear on the side in which the abdominal muscles are in spasm (Figure 7) The anterior superior spine of the pelvis will be noted to stand out prominently in the condition of abdominal muscle spasm with shortening

Knees Held in Flexion—This position is usually assumed by the patient to relieve tension in the hamstring muscles which are always in spasm Shortening of the hamstrings in spasm interferes with action of the opposing quadriceps (Figure 8) and the quadriceps may become alienated Spasm of the hamstrings also causes a decrease in the depth of the gluteal crease of the buttock



Figure 7 Pelvic tilt and apparent leg shortening due to spasm of left abdominal muscles (untreated case after thirteen months)



Figure 8 Acute infantile paralysis Spasm of the ham string muscles prevents extension of the knee (In the untreated case, these structures are frequently found still in shortened condition years later)

Widening of the Natal Cleft —Spasm of the gluteus maximus causes the buttocks to be separated widening the natal cleft, and in extreme cases it may be observed that the anus is actually exposed The buttock is flattened by spasm of the gluteus maximus and the gluteal crease is diminished

Lower Extremity in External Rotation —This condition is usually caused by spasm of the tensor fasciæ latæ in conjunction with spasm of the biceps femoris Spasm of the tensor alone causes the knee to assume a valgus position The condition of spasm of the tensor fasciæ latæ is easily overlooked but palpation of the tight iliotibial band laterally just above the knee confirms the presence of the spasm and shortening of the muscle

Direct Foot Drop or Equinus —Spasm of the calf muscles as a group cause this condition It will be found impossible to dorsiflex the foot even with force and an attempt to do so will cause pain in the calf The opposing anterior tibial muscle, being persistently pulled beyond its normal resting length, becomes alienated and appears to have no power The patient frequently attempts to relieve spasm and pain in the gastrocnemius by flexing the knee Permanent equinus deformity will result if the condition of spasm affecting the calf muscle is not relieved by proper treatment

Heel Held in Inversion or Supination —The individual parts of the calf group may go into spasm independently and cause disalignment of the foot or heel according to the muscle part involved Persistent supination of the heel is the result of spasm of the medial head of the gastrocnemius The peroneal muscles are caused to become alienated A varus deformity will eventually result if the spasm is untreated

Heel Held in Eversion or Abduction —Spasm of the lateral head of the gastrocnemius is responsible for this position The anterior tibial and posterior tibial muscles are usually caused to become alienated by being persistently removed from their normal resting lengths A valgus deformity of the foot will eventually result if the muscle condition is not treated

Foot Held in Dorsiflexion —This condition is due to spasm of the tibialis anterior muscle (Figure 9) The opposing gastrocnemius muscle becomes alienated Failure to treat the muscle condition will eventually result in a calcaneus deformity and permanent inversion and adduction of the forefoot

Other examples could be mentioned, as spasm is a condition which may affect any of the skeletal muscles of the body in the acute stage of infantile paralysis, but those cited are some of the most commonly observed Careful watch of the entire body must be maintained at all times for the appearance of abnormal alignment, as spasm may occur in muscles which were presumably not affected at the time the patient first came under observation Prompt steps must be taken to relieve the muscle condition A delay as long as three weeks may mean irrevocable harm to the muscle tissue Correction of these deviations of alignment by force, as in applying splints or casts, is obviously not a rational procedure Muscle in spasm has exaggerated tonus and responds to stimulation as does any other irritable tissue, that is, by becoming more irritable and increasing the spasm The proper application of moist heat to the area affected, as will be described in the succeeding chapters, will accomplish the desired relaxation of the muscles in spasm and will eliminate



Figure 9 Acute infantile paralysis Spasm of the tibialis anterior muscle causes its tendon to stand out prominently The foot is held in dorsiflexion and the forefoot in inversion by the pull of the shortening muscle This is the beginning of a varus deformity

the possibility of the occurrence of any permanent de formity Treatment can not be considered as com plete until all muscles have been restored to full length as evidenced by complete and unrestricted range of motion in every joint of the body

As the acute muscle spasm subsides under treat ment it becomes possible to examine the state of all of the disturbed neuromuscular system It will be re called that infantile paralysis is a disease character ized by mental alienation of muscle incoordination of muscle action and by muscle paralysis in addition to the symptom of muscle spasm

Detection of Mental Alienation —The condition of spasm in a muscle is associated with a disturbance in the physiological behavior of its opponent as a result of which this muscle is caused to become alienated or divorced from the voluntary motor center The pa tient loses awareness of the non functioning muscle When it is noticed that a muscle has lost its power of contraction the first procedure is to observe wheth er the opposing muscle or group is in spasm and if so it may be assumed that the non functioning mus cle is alienated An alienated muscle suffers from a physiological interruption in the motor pathway Such muscle was considered by orthodoxy as typical of the flaccid paralysis of infantile paralysis for which splinting in a position of rest was designed In reality this muscle is the non affected muscle It may be recognized by the following points

1 The alienated muscle is neither painful nor tender
2 Its opponent is usually in a condition of spasm and frequently there is a disalignment of the

contracting the posterior neck muscles and push himself up It is obvious that *attempts to restore the* anterior neck muscles would never succeed but rather would alienation of these muscles become permanent if the impulses designed to stimulate these muscles were always directed to the opposing posterior neck muscles Substitution of muscles encourages incoordination in the region and must never be allowed Although power is lacking in some of the muscles every muscle in a reaction must contract in its rhythmic sequence even *if it does so only in the mind of the patient if coordina* tion is to be restored

Incoordination is really of two types

1 That occurring from misdirection of nerve impulses to otherwise normal muscles This type of incoordination has just been described and is evidenced by
   (a) Opposing muscles contracting simulta neously in attempting to perform a given movement
   (b) A muscle incoordinately attempting to *perform the primary action* of another muscle although this muscle is itself strongly acting
   (c) Incoordinate contraction of muscles not concerned with the given joint move *ment*

2 That due to misdirection of the nerve im pulse to the muscle fibers *within the indi vidual muscle itself*

The second type is most apt to appear *in those mus* cles which normally have the ability to pull from either end as *for example the sternomastoids* and the ham

strings The patient may expend most of the potential power of a muscle by mistakenly pulling from the origin rather than from the insertion for the action desired The attendant must observe these muscles to be sure that they pull in a smooth, graduated manner from the point of insertion An incorrect action is evidenced by a bunching of the muscle belly at or near the origin of the muscle when the patient attempts to produce a motion at the opposite end or insertion of the muscle The hamstring group, in performing knee flexion, is apt to show this behavior and the observer will note the incorrect action by the sudden contraction of the muscle belly near the tuber ischii rather than the normal smooth graduated pull beginning from the tendons at the knee

Where the bony attachments at both ends of a muscle are movable, the muscle may even expend its effort in actually producing motion at the opposite end to that desired The sternomastoid muscle is a typical example The incorrect action when trying to forward flex the head will be observed by the fact that the chest is caused to raise rather than the head to flex when the muscle contracts

Detection of Paralysis —It is impossible to determine early in the disease of infantile paralysis whether or not actual paralysis is present The mere fact of loss of ability to contract a muscle does not necessarily mean injury or destruction of the anterior horn motor cells of that muscle Most non functioning muscles are merely alienated in association with the presence of spasm in the opposing muscle Real paralysis when it appears has the tendency to affect all

of the muscles of a region of the body including the opposing muscles The condition of spasm precedes the onset of paralysis in a muscle Spasm present in both of the muscles opposed to each other is an unfavorable sign and frequently means that paralysis will eventuate in both Absence of contractile power in both of the opposing muscles noticed when the patient first comes under observation, usually is indicative that spasm has been present and spasm may or may not still be present in one or both of such muscles Determination of paralysis in any case is only possible and acceptable after complete relief of spasm and after all attempts at restoration of function of muscles have failed to elicit voluntary contractile response The detection of paralysis, therefore, does not constitute a part of the examination of the patient in the acute stage of infantile paralysis

RECORD

An *appropriate and satisfactory chart* for the purpose of recording the condition of the patient and for following the progress would list the findings under the headings of muscles in spasm disalignment or incipient deformity, alienation, and incoordinated muscle actions

NURSING CARE

Treatment of the Patient in the Acute Stage

IMMEDIATELY that the diagnosis of infantile paralysis has been established and the condition of the patient evaluated by the attending physician the nurse must assume the responsibility for the welfare of the patient He suffers from a disease which threatens first his life and second the future efficiency of his motor system Treatment will have for its object the preservation of life and the restoration of function of the neuromuscular system Nursing of the disease requires extraordinary attention to detail alertness for the interpretation of unfavorable conditions and ingenuity in the application of methods to relieve distress No disease demands a higher degree of nursing skill The recovery and future welfare of the patient will be dependent to a large extent on the quality of nursing care administered during the early period of treatment in the acute stage It is therefore highly important that the supervising nurse be especially trained and experienced in the handling of patients afflicted with the disease of infantile paralysis if satisfactory recovery is to be expected Close cooperation between the nurse and doctor will be necessary in sav

ing the lives of many patients Admission of the patient to a properly staffed and equipped hospital is desirable wherever possible

The first concern is for the comfort of the sick and distressed patient Besides the general constitutional manifestations of the disease he suffers from painful muscle spasm and is apprehensive of being touched or moved Spasm is a condition damaging to muscle tissue and great care must be exercised not to encourage or increase the disorder A most important principle to be observed throughout is that handling and moving of the patient be reduced to a minimum in order not to excite further muscle spasm Handling and moving of the patient should be only that necessary for the comfort and care of the patient All motions whether attempted by the patient or performed by the attending nurse have the effect of aggravating the condition of muscle spasm and are not to be encouraged The patient should be fed and completely attended during the acute stage Since spasm is frequently aggravated by voluntary attempts on the part of the patient to immobilize himself for the relief of pain by contracting his muscles it is important that all measures to encourage both physical and mental relaxation be employed Fear must be allayed and stimulation of the patient avoided Relief of spasm is accomplished by the application of moist heat to the areas affected a procedure which will be taken up in detail in the chapter to follow Spasm which affects the muscles of respiration and those of the neck and upper trunk may threaten the life of the patient by interfering with breathing Such patients become very apprehensive and must be care

fully attended During the early period, when muscles in spasm are severely painful, the patient is allowed the position in bed which brings the greatest amount of comfort and relief Frequent changes in position are sometimes necessary to make the patient comfortable, and pads and pillows may be used temporarily as props to ease the painful tension in the muscles With the subsidence of painful spasm, a position of normal alignment in bed is encouraged (Figures 10 and 11)

The patient is placed upon a flat bed with a cotton or felt mattress Bed boards placed lengthwise between the mattress and the spring give a firmer surface and greater stability Blankets are used instead of sheets as they give greater warmth and are less irritating All bed wear is omitted from the patient in order to avoid irritation of the receptor nerve endings in the skin which would tend to set up further muscle spasm by reflex action The room should be kept somewhat warmer than usual and no drafts allowed to blow across the patient A cradle serves to relieve the body and limbs of any weight of bedclothes (Figures 12 and 13)

It will be observed that many patients on admission are distended, apparently because of intestinal stasis and frequently have retention of urine It is advisable and usually of considerable relief to every patient to attend to these functions by administering a cleansing enema and by catheterizing the bladder if spontaneous voiding does not occur Otherwise the giving of baths and attention to lesser details of the toilet are not of sufficient importance early in the disease to warrant disturbing the sick patient unnecessarily



Figure 10 Acute infantile paralysis *Normal position of the patient in bed*

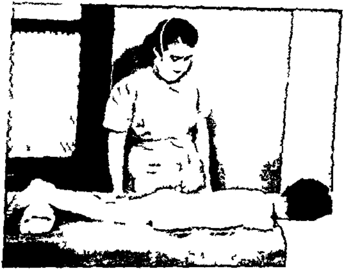
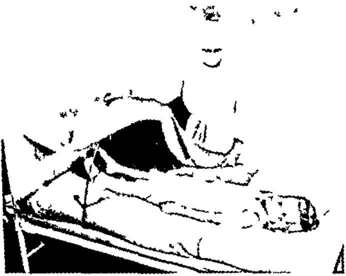


Figure 11 Acute infantile paralysis Prone position in bed Notice in both prone and supine positions that the pad placed under the shoulder and upper extremity helps to maintain the normal alignment of these parts



F gure 1° Pos on n bed for acu el ll pat ent Hot packs ha e been appl ed to regions of body affected b mu cle spasm Not ce that the feet are not pl ced aga nst the foot board when there s spa m n the calf muscles



F gure 13 Completed bed w th acutely ll pat ent The cradle keeps the bedclo hes off the patient s feet

The administration of fluids and food is of some concern as the patient frequently has been unable to retain these substances and has in addition become dehydrated through fever With the relief of distention and by patiently administering small amounts of some desired fluid with a spoon, the patient can usually be encouraged to swallow enough nutritive substances to satisfy his needs The diet should consist of foods desired by the patient Milk and milk products should be avoided if there is a tendency for mucous to collect in the throat Pineapple juice and the citrus fruit juices are especially good and will help to cut the phlegm Albumen water, made according to the following formula, is sometimes helpful in coun teracting the mucus

- 1 egg white—cut several times
- 2 teaspoons of brandy for an adult (or 1 tea spoon for a child)
- ½ teaspoon of sugar
- ½ cup of water

The introduction of fluids by tubes through the nose or mouth is disturbing to the patient and is not recommended, as this procedure excites spasm, increases the mucus, and interferes with swallowing Where there is actual difficulty in swallowing as in the bulbar case, or where the patient is unusually restless and uncooperative, it may be necessary to sup plement the amounts of fluids by parenteral means Rectal instillations are usually well tolerated and ap parently are absorbed The albumen water or normal saline with 5 per cent glucose may be used Sub cutaneous fluids are painful and tend to increase the spasm in muscles adjacent to the site of injection

It is seldom necessary to resort to intravenous methods except in the moribund patient

The bulbar type of case with difficulty in respiration constitutes a real emergency and patients must be carefully observed for any sign of this disorder The collection of saliva or mucus in the throat and difficulty in swallowing are indicative that the disease is attacking the bulbar portion of the nervous system and that the vital respiratory centers may be shortly affected Patients exhibiting these symptoms must be regarded as dangerously ill and must be carefully attended The throat must be suctioned frequently to clear retained secretions in order to make the patient more comfortable as well as to prevent aspiration of fluid into the lungs The cough and gag reflexes disappear and the patient literally tends to drown in his own secretions which are continually aspirated into the lungs The administration of food and fluids to these patients is slightly hazardous because of the same risk of aspiration This can usually be safely accomplished however by patiently giving small sips of fluid with a spoon at frequent intervals In this case also milk and milk products should be avoided but the citrus fruit juices or the albumen water will help clear the mucus Propping the patient up in a semi reclining position when giving fluids will aid him in swallowing

The condition of patients with the bulbar type of the disease is difficult to judge They often appear to be thriving and recovering only to suddenly slip backward and succumb The special care required for all types of respiratory disorders will be taken up in detail in the chapter on respiration

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The basic position of the patient in bed after the first twenty four or forty eight hours, when the spasm may be severe or painful is that of correct body alignment By this is meant that the head and limbs shall bear the most nearly normal relationship to the body which they naturally assume when the person is in the standing position (Figures 10 and 11) Man is an orthograde animal and moves in the erect position Gravity modifies this posture in the reclining position and great care must be taken to retain the normal relationship of the parts when the patient is in the supine position

Consideration of the normal standing posture discloses the head to be erect the hands at the sides and the feet to be slightly apart In this position all muscle fibers are approximately at rest with no undue stretching or contractions It would be impossible to conceive that in designing the posture nature would have placed muscles in such position that they would be under any particular constant tension The position of rest can be maintained during the entire acute and convalescent stages without fear of harming muscles by stretching If deformities are to be avoided the limbs should be placed not in unnatural positions but in the posture they would normally occupy These are the zero positions from which a range of movements in various directions shall be sought in restoring normal functional conditions to muscles affected by the disease

The posture described is maintained as far as possible during the major portion of each twenty four hours of the entire convalescence The patient is not disturbed if he prefers to lie on his side during the

night time A prone position is substituted for two periods of one hour each during the daytime for the comfort afforded by the change of attitude If a limb tends to rotate outward or any part of the body tends to fall out of true alignment the cause must be immediately investigated If the disalignment is due to spasm the condition must be treated and no attempt made to forcibly restore alignment of the part If the disalignment such as the limb rolling into external rotation is due to muscle weakness the limb may be supported at the joint by a soft pad or cushion (Figure 14) Apart from this all pressure especially on bony points is carefully avoided On admission the patient may prefer to lie with certain joints flexed in order to relieve the tension and pain in muscles in spasm Moist heat quickly relieves the pain and the proper position of correct body alignment is readily assumed

The condition of spasm affecting various muscles will determine special positions to be used for treating individual cases This will be taken up in the following chapter dealing with the treatment of muscle spasm

An upright board of sufficient width to extend above the toes is fastened solidly to the foot of the bed The mattress is kept back from the board by two four inch blocks placed one to each outer side The space between the mattress and the footboard provides a place for the heels when the patient is in the supine position and for the forefoot when the patient is in the prone position (Figures 15 and 16) The feet are placed against this upright board only when acute painful spasm in the lower extremities has subsided



Figure 14 Natural position in bed when there is no active spasm in the lower limb A soft pad at the knee prevents the lower limb from falling into external rotation A folded towel at the wrist keeps the hand in normal position A pad under the shoulder and entire upper extremity keeps these parts in normal alignment



Figure 15. Normal position in bed after acute spasm in the calf muscles has been relieved. Correct body alignment is maintained throughout the period of treatment



Figure 16. Prone position. The feet are firmly applied to the footboard in both prone and supine positions for the purpose of stimulating the *standing reflexes*

The *footboard is in no* sense a splint for maintaining dorsiflexion of the feet Splinting for the purpose of immobilization does not constitute any part of the treatment Splints were designed for a disease in which *flaccidity and laxness of muscle* were considered to be the outstanding characteristics and therefore, would not be applicable to a disease in which spasm and shortening of muscle are the predominant symptoms to be *treated Splinting would* obviously prevent or hamper the treatment of the muscles and would tend to increase the undesirable *and damaging condition* of spasm in the hyperirritable muscle tissue The poor circulation and trophic changes which formerly were observed in the limbs of patients were largely a result of splinting and the *failure to give proper treatment to the tissues in the* acute stage

The footboard serves the purpose of providing the sole of the foot with a solid contact This serves to re establish and to stimulate the normal standing reflexes which are comparable to the extensor responses of the decerebrate experimental animal *Contact of the sole of the foot against a solid surface* induces normal contraction of all standing muscles and thus aids in the restoration of function of these muscles The psychological impression of standing *while lying in* bed is complete by maintaining correct alignment of the body while the soles of the feet have solidity of contact Spasm of the calf muscle especially is a contra *indication to placing the feet against* the board The resulting stimulation tends to aggravate the condition of spasm in the calf muscle

With the relief of active spasm in the lower *leg* mus

cles, the feet are placed firmly against the footboard and the patient instructed to push against this board during the daytime. It is highly important that the body be maintained in correct alignment flat in bed during the major part of the course of treatment. Sitting up for short periods of one half hour daily is allowed only when painful muscle spasm has been entirely relieved and when most of the shortened musculature has been relaxed. No activity is allowed in the presence of incoordination of muscle action.

Because of the long convalescence required for the disease, it is better to place children in wards rather than in individual rooms. They thus entertain each other and keep up the general morale. Playing with many toys should be discouraged and the few playthings allowed children should be of the most simple type.

The smaller children would appear to be difficult to manage but this does not prove to be a problem. During the stage of acute painful spasm they are content to lie quietly in bed in the prescribed position. As recovery ensues the small child tends to resume his previously uninhibited activity. The tendency to stand up and move about in bed is not to be encouraged if ways can be found to keep the child quiet. It is unnecessary to discipline such a child and in fact it is unwise to restrain him in bed. The small child is still largely an automatic mechanism with little selective control of muscle. There is therefore less tendency for substitution of muscle and incoordination of muscle action to develop. Voluntary efforts of the small child are less harmful to the disturbed neuromuscular system than are those of the more mature child or adult.

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With the relief of active spasm in the lower leg mus

TREATMENT OF MUSCLE SPASM

Preparation and Application of Hot Foments

The relief of muscle spasm and pain is the main consideration of nursing having to do with the preservation of the neuromuscular system. The treatment, to be effective, must be instituted as soon as possible after the patient comes under observation. This is a highly important and specialized therapeutic procedure employing the application of hot foments to the areas involved and having for its primary object the relaxation of muscle fibers in order to restore the affected muscles to full normal length, softness, elasticity and receptivity to stimuli. Moist heat will accomplish the desired effect by relieving muscle spasm better than any other form of heat. This form of treatment will also prove efficient in assisting the circulation and preserving the vitality of all the tissues as well as relieving the hypersensitivity of the skin. An improved circulation aids in the recovery of the affected muscles by increasing the available oxygen and by removing toxic substances which tend to accumulate in the tissues. The specific methods to be described have been found effective and should be exactly followed.

While the determination of the muscles involved by spasm and the treatment to be applied is the re-

The special province of the nursing service will be that of the application of moist heat for the relief of pain and muscle spasm This important subject will be taken up in detail in the chapter to follow

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While the determination of the muscles involved by spasm and the treatment to be applied is the re-

sponsibility of the attending physician, the nurse must have an exact knowledge of the position and the extent of *the particular muscles in order that the foment* be accurately and efficiently applied. It must be kept in mind at all times that the acutely ill patient must be attended gently and with a minimum amount of handling and manipulation in order not to excite *further spasm in the hyperirritable muscles.* Grasping the patient over muscular areas for the purpose of turning or moving is particularly to be avoided. Massaging or rubbing excites spasm and is very damaging to the sensitive muscle tissue. The patient is *never sat up but is gently turned upon the side as* necessary for applying the hot foments. Maintaining as nearly the normal body alignment as possible during the time of changing the packs will assure that muscles are not being placed under tension (Figures 17, 18 and 19). *It is perfectly feasible that a large part of* the actual manual labor of applying the hot foments and packs can be efficiently done by trained maids or nurses' aides, assisting the nurse.

The moist foment is prepared *from wool flannel* blanket. This is *preferably of old blanket because* of the lesser tendency for the old material to shrink and become bulky with repeated boiling. Blanket *of pure wool has been found to* be best but material with a wool content of at least 75 per cent has been proven perfectly satisfactory. Cotton material clings to the skin and is not recommended because of the danger of burns. Wool retains heat well and at the *same time the fuzzy* surface keeps the cloth from adhering too closely to the skin. It is unnecessary to apply ointments to the skin to *prevent burning.*

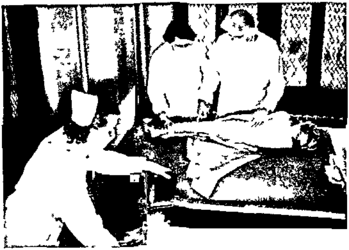


Figure 17 Acute infantile paralysis Preparation for the application of the thigh pack



Figure 18 The hot foment is being applied Note the covering layers in position ready for the immediate completion of the pack



Figure 19 Acute infantile paralysis The application of the back pack This is held in position with a binder Note the maintenance of body alignment during the application

The material is cut and stitched to be in double layer and appropriate to the size of the patient Pieces will be in the shape of squares rectangles or triangles depending upon the part to be packed (Figures 20 and 21) It is important that the foment be of sufficient size to cover the full extent of the muscle being treated otherwise the proper effect will not be obtained in relaxing the muscle The moist foment is protected and its heat preserved by dry covering layers and the whole application constitutes a pack The entire pack consists of the following

1 The inner moist foment of a double layer of wool flannel
2 A single layer of light waterproof material such as oiled silk
3 A single layer of dry flannel
4 A single outer layer of cotton flannel or terry cloth

All layers are cut to the same size and shape for the part to be packed In order to facilitate application, the dry layers are usually placed in position on the bed handy to the area being packed The foment flannels are boiled in a sterilizer and on removal from the boiling water are then run quickly twice through a tight laundry wringer It is important that all droplets of water be squeezed from the foment in order that burning be avoided The entire group of foments for the patient is enclosed in rubber sheeting to preserve the heat and is taken at once to the bedside of the patient The foment is immediately applied firmly to the selected area and the pack quickly completed by the application of the covering layers The binding layer of flannel or terry cloth is secured with safety pins

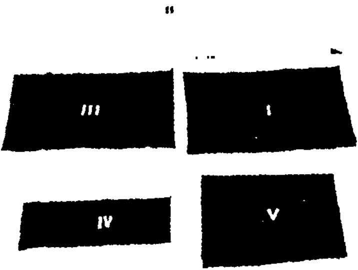


Figure 20a *Form and shape of the foments for the muscles of the back, abdomen and lower extremity*



F gure 20b The pos tion of the app ed foments for the muscles of the back ab lomen and lower extrem ty (See I II III IV and V)

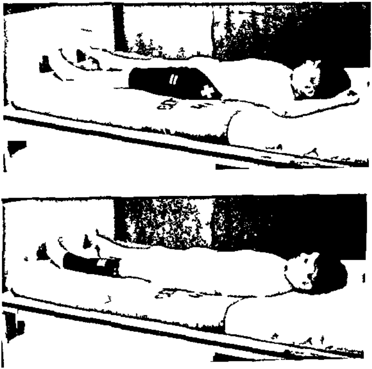


Figure 20b (Continued)

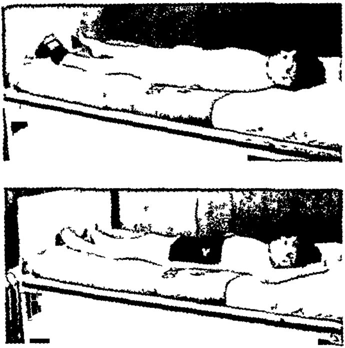


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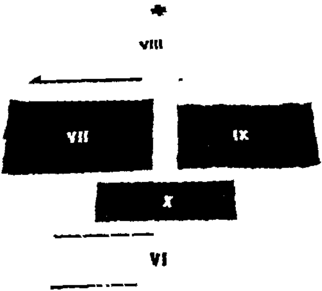


Figure 21a Form and shape of the foments for the muscles of the neck, chest and upper extremity

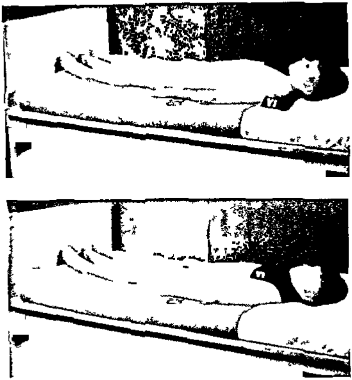


Figure 21b Position of the applied foments for the muscles of the neck chest and upper extremity Notice that the neck pack does not encircle the neck (See VI VII VIII IX and X)

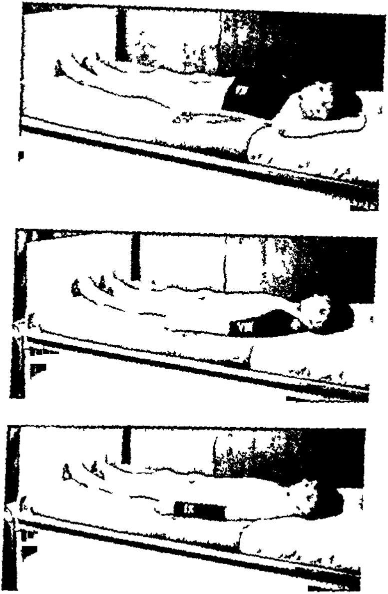
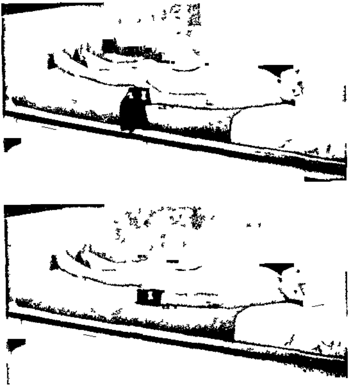


Figure 21b (Continued)



F gure 21b (Cont nued)
Note that the thumb is covered in the *second* wrap of the hand foment

The packs should not be awkward or bulky and they should never constrict so as to interfere with breathing swallowing or circulation

A most important point to observe is that the packs do not extend over joints except where the position of muscles makes this necessary (Figure 22) The patient must not be given any impression of immobilization but rather should be allowed to realize that free motion is possible in every joint At the ball and socket articulation of the hip and shoulder where muscles extend over joints the covering of these joints is unavoidable

Following the application of the packs, care is taken that the patient is placed in normal body alignment in bed and that this position is maintained throughout the course of treatment (Figures 23 and 24) In the usual case, the packs are renewed every hour during the acute stage and every two hours during the convalescent stage throughout twelve hours of each day The usual period is from 8 00 A M to 8 00 P M In dealing with numbers of patients, it is well to have a sufficient supply of extra foments that have been sterilized by boiling before they are applied each time In renewing the pack, the wet foment and the waterproofing material are removed but the other covering layers are merely unfolded and left in convenient position for reapplication

Where the condition of painful muscle spasm is very acute and endangers life, as in the case of the respiratory mechanism, the hot foments may be applied as often as every few minutes to the muscles concerned with breathing and swallowing Special attention is given to the neck muscles, the intercostals, and the pec-



Figure 22 The thigh and calf packs in position Note that the knee joint is not immobilized

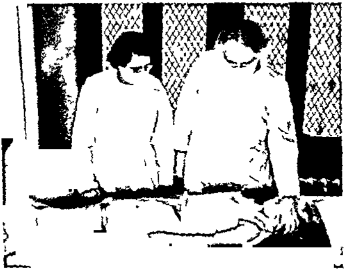


Figure 23 Acute infantile paralysis The patient is in normal alignment following the application of the hot packs In this case the upper extremity was not involved so that no packs were used over this area Note the method of keeping the neck pack in place without encircling the neck



Figure 24 Acute infantile paralysis The normal prone position with packs applied

torals for this reason The spinal muscles should also be packed in this case but not necessarily as frequently as those just mentioned Such concentrated packing is not done over any prolonged interval of time, usually for periods of fifteen minutes to an hour, because of the fatiguing effect upon the patient In such case, the entire pack is not always used but frequently just the hot foment alone or the hot foment plus the waterproofing covering Light weight flannel usually of just a single layer is preferable and the hot foment is gently placed over the involved area without attempting to encircle the region or bind the foment in place During the first twenty four or forty eight hours of the disease, when the patient may be critically ill the attention should be devoted entirely to the affected muscles which are endangering life by interfering with breathing or swallowing The extremities may be disregarded entirely during this period unless there is pain which is disturbing In these serious cases where the spasm is especially painful or where breathing is difficult the hot foments are applied during the *night to relieve the patient if he awakens because of* distress As a general thing the patient is not disturbed for hot packs during the night as rest and relaxation are also essential to his recovery

Muscles in acute spasm are hyperirritable The tension produced in certain of these muscles by the forces of gravity or the weight of the limbs sometimes causes spasm to be increased and pain to become intense in these muscles In order to relieve pain and successfully combat the condition of spasm it is necessary in such case to relieve the tension and relax the muscle by placing the body temporarily in

such position that the attachments of the muscle are brought closer together An example frequently en countered is that of the abdominal muscles Figure 25 illustrates the method of relaxing these muscles by flexing the hips and supporting the lower extremities on pillows This position is maintained and concen trated hot packing applied until such time as the position of normal alignment of the body no longer causes exaggeration of spasm in the abdominal mus cles

The position for relaxing the spinal muscles is shown in Figure 26 The patient is placed in this position for periods of one hour several times daily while concen trated hot packing is employed

In some cases the spasm of the hamstring muscles is so severe that the patient attempts to keep the knees flexed in order to relieve the tension in these muscles Placing a pad or pillows temporarily beneath the knees to flex them slightly will allow the hamstring to relax and the condition of spasm can then be successfully treated Where such procedures are employed they are always temporary The patient must be placed in a position of normal bodily alignment as soon as the condition permits This can usually be accomplished within two to three days but may be longer in some cases The patient must be watched for any tendency for a recurrence of the abnormal condition

With a little practice the attendant is able to apply even a complete body pack efficiently in a short space of time and with a minimum of effort The hot packs are continued daily throughout the entire convales cence until all spasm and shortening tendency in the muscles has been relieved This is indicated by the

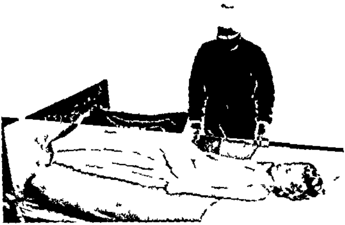


Fig 25a Acute infantile paralysis The body position for relaxing the abdominal muscles when the condition is painful and severe

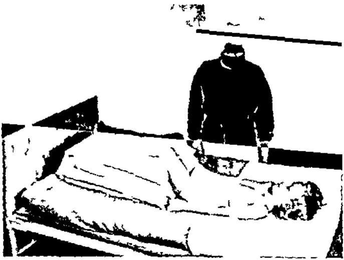


Figure 25b The position of the hot foment for treating the abdominal muscles



Figure 26a Acute infantile paralysis The body position for relaxing the spinal muscles when spasm is very acute or painful

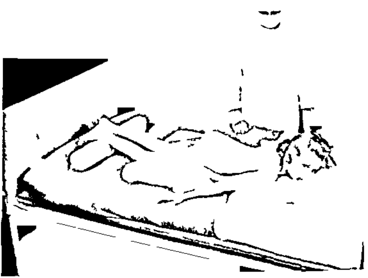


Figure 26b The position of the hot foment for treating the spinal muscles

recovery of complete normal range of passive motion in every joint The painful acute muscle spasm usually disappears within two weeks In the average patient with an attack of moderate severity, if he comes under proper treatment early, the affected muscles will attain full relaxation and normal length usually by the end of six to eight weeks In the stubborn case, concentrated packing should be employed using a light pack every fifteen or thirty minutes for the twelve-hour period during the day The tendency for some muscles, particularly the hamstrings, to remain in a state of contraction or temporary shortening may persist for months and these must be noted and assiduously attended until full relaxation is attained With persistence, complete relaxation and full length can be secured in every muscle The condition of muscle shortening is particularly obstinate where treatment has for any reason been delayed early in the disease

It has been observed that the hot foment cools to approximately body temperature usually within fifteen minutes of its application The moist foment is nevertheless, left in position until changed at the end of each full two hour period in the ordinary case No attempt is made to keep the foment warm by the accessory use of hot water bottles or other devices The mere heating of regions of the body or of the whole body is not the entire object of the foment, nor is maintaining the application of continuous heat desirable The alternate heating and cooling obtained by the packing method has a much more beneficial effect in the re establishment of circulation and result

ing improvement in the vitality of the tissues of the affected area Dry heat in any form has not proven efficacious

THE RESPIRATORY SYSTEM

PATIENTS who fail to survive an attack of infantile paralysis usually have some form of respiratory disorder preceding death The cause is not the same in each case and it is therefore necessary that the various conditions causing respiratory failure or interference with breathing be recognized by those attending the acutely ill patient This must be done in order that all appropriate measures may be applied according to the individual circumstances There is no situation where life is in more precarious balance Correct nursing procedures may mean the difference between success or failure in preserving the life of the patient There are many factors involved in the process of breathing and it is logical to expect that disorders of respiration may be of different character There are muscles directly concerned with inspiration and with expiration, and muscles accessory to these actions Regulating the respiratory movements and coordinating the muscles of respiration is the respiratory center situated in the bulb or medulla oblongata of the nervous system

Disorders of the breathing mechanism are of four main types

1 Bulbar, due to paralysis of the regulating

center in the medulla oblongata by the direct action of the virus upon nerve cells

2 Inspiratory, due to spasm of the intercostal muscles which prevents elevation of the rib cage and expansion of the chest

3 Expiratory, due to spasm of the diaphragm which prevents the deflation of the expanded chest

4 Paralytic, due to paralysis of the respiratory muscles by action of the virus upon the anterior horn cells of the spinal cord

Bulbar Respiratory Paralysis—This is the most treacherous type of respiratory disorder and the one *lease predictable in outcome* The condition is recognized by the following points

1 Respiration is shallow and irregular both in rhythm and depth
2 Cyanosis is usually not marked
3 The patient has difficulty in swallowing and secretions tend to collect in the throat
4 There are disorders of phonation
5 The patient usually has apparent paralysis of palatine and pharyngeal muscles and sometimes the facial muscles The patient regurgitates fluids through the nose
6 The patient often has apparent paralysis of the neck and shoulder muscles

The bulbar type of respiratory disorder is due primarily to the action of the virus upon the respiratory center and upon the cranial nerve nuclei While it is quite impossible to treat directly the source of the trouble there are procedures which will add to the comfort of the patient as well as assist him through the danger period

The difficulty in swallowing is especially of importance Secretions tend to collect in the throat and in the trachea and there is constant danger of aspiration The patient literally tends to drown in his own secretions Pneumonia may result and be a contributory cause of death Frequent suctioning with a soft rubber catheter is the procedure to keep the respiratory tract clear The patient is much more comfortable by this procedure and will often drop off to sleep after suctioning

Restlessness is a common feature and the patient demands frequent change of posture For the most part the patient may be allowed to lie in bed in his position of choice He may find it easier to clear secretions from the throat and trachea by lying on his face or with the head partially off the edge of the bed Packs for the relief of spasm in the extremities or in portions of the body not concerned with breathing and swallowing may be delayed pending the relief of the respiratory disorder

An important contributing factor to the difficulty in swallowing as well as breathing, is that of spasm of the posterior neck muscles with a tendency for retraction of the head Immediate steps must be taken to relieve spasm of these structures by the concentrated application of hot foments Administration of food and fluids is difficult because of inability to swallow and the danger of aspiration but is usually successfully accomplished by giving small amounts of fluids with a spoon Propping the patient up for feeding is helpful Feeding tubes should not be inserted into the esophagus because of disturbance of

the patient and resulting increase of secretions from the irritation of the tube In some cases it may be necessary to give fluids by intravenous injection but this procedure is seldom necessary as rectal instilla tions are usually well retained

The use of the mechanical respirator is never indi cated in the treatment of bulbar paralysis It is prac tically impossible to synchronize the regular pulsations of the machine with the disturbed breathing of the patient which is usually irregular in rhythm As a result the distress of the patient is increased by the respirator There is a further serious chance of the respirator being responsible for the aspiration of secre tions into the lungs of the patient The respirator is contra indicated in bulbar paralysis

Inspiratory Respiratory Disorder—Inspiration, or the drawing of air into the lungs by expanding the thoracic cavity is accomplished by the action of the respiratory muscles These consist principally of the intercostal muscles and the diaphragm A number of accessory muscles assist under stress most notable of which are the sternomastoids and the pectorals The abdominal muscles are accessory to respiration only in the phase of exhalation and are therefore to be considered as opponents to the muscles of inspira tion The intercostal muscles are supplied characteris tically by spinal nerves and are therefore subject to the affections of all skeletal muscles by the disease of infantile paralysis That is to say, spasm is a condi tion frequently affecting the intercostal muscles and responsible for the distressed respiration Interfer

ence with inspiration, due to spasm of the chest muscles, is recognized by the following points

1 Respiration is regular in rythm but rapid in rate
2 Cyanosis is usually marked
3 The chest is rigid or has little excursion be cause of the immobilizing effect of spasm in the intercostal muscles The patient is un able to take a deep breath or to hold his breath
4 The pectoralis major muscles are often in spasm contributing to the immobility of the chest (Figure 28)
5 The sternomastoids accessory inspiratory muscles attempt to assist inspiration and are themselves frequently in spasm (Figure 27)
6 The affected muscles are frequently painful and tender
7 The posterior neck muscles are very often in severe spasm
8 Difficulty in talking is usually due simply to inability to inhale sufficient air to accom plish phonation

Alienation and incoordination also appear in the muscles of respiration It has been frequently pointed out that muscles of the shoulder girdle are often apparently paralyzed in those patients having respira tory distress This has been considered as evidence that paralysis was also affecting the intercostal muscles In reality these non functioning muscles are alienated and reflexly inhibited in order to protect the painful inter costal muscles in spasm

Spasm of the intercostal and pectoral muscles is fre



Figure 27 Acute infantile paralysis *Persistent spasm* of the sterno mastoid muscles noted in the condition of inspiratory distress



Figure 28 Acute infantile paralysis The patient had considerable respiratory distress due to spasm of the intercostal and pectoral muscles *Spasm of the pectoralis major muscle prevents abduction of the arm* Note the typical elevation of the shoulder as the patient attempts to relieve the pain in the pectoralis which has been placed under tension

quently the condition responsible for difficulty in breathing in acute infantile paralysis These muscles in spasm are frequently painful and the areas of the chest where spasm is particularly active may be noted to be actually depressed The pectoral muscles in spasm contribute to the immobility of the chest by binding down the ribs (Figure 28)

There is but one indication for treatment in this type of respiratory distress Spasm of the affected respiratory muscles must be promptly relaxed by the use of hot foments Packs should be applied frequently to the neck to relieve head retraction due to spasm of the posterior muscles Packs to the thoracic part of the spine are important but should not be changed frequently if the patient is distressed by being turned The packs to the chest are applied to the entire anterior and lateral areas and particularly to the pectoral regions if these muscles are tight If breathing is especially difficult or painful the chest packs may be applied every few minutes for one half hour or more until respiration is improved but only the hot foment itself without the covering layers is used for this treatment The periods of concentrated heat should be repeated as frequently throughout the twenty four hours as indicated by the condition of the patient but he is never awakened for this procedure As turning the patient becomes easier the back pack is also applied but these are changed only every hour or as often as the position of the patient allows because of the difficulty and distress in shifting the patient The throat must be kept clear of secretions by suctioning The patient with pure inspiratory distress is usually able to swallow and to take a fair amount of fluids by

mouth Fluids and nutrition must be attended by parenteral administration if the patient is unable to swallow Tubes inserted into the throat increase the difficulty in breathing *and also increase the spasm*

It is obvious that forceful attempts to expand the chest by such means as the mechanical respirator would only tend to increase the spasm of the intercostal muscles Enclosing the patient in the respirator furthermore *makes treatment of the muscle spasm* by hot foments difficult or impossible The use of the respirator in this type of case is therefore opposed to the object of treatment *that is relaxation of the muscles of* respiration While some patients with intercostal muscle spasm may survive the use of the respirator the chance of restoring the respiratory muscles to useful function is very much diminished because of failure to properly treat the condition of spasm during the acute stage of the disease In general patients of this type who die while receiving hot packs without the respira*tor would also die if treated by the respirator* The respirator for use in infantile paralysis was designed for a disease in which the muscles were considered to be flaccid and paralyzed The respirator is therefore of no use in the treatment of respiratory distress due to intercostal muscle spasm

Expiratory Respiratory Disorder—The diaphragm is an important muscle of respiration In contracting it causes the thoracic cavity to enlarge and the patient to inspire The *diaphragm is muscular* and is innervated by spinal nerves and therefore subject to the affections of all skeletal muscles in the disease of in*fantile paralysis* Spasm of the diaphragm causes per

sistent involuntary contraction of this structure and unreleasable expansion of the chest The patient has difficulty in exhaling and he will be observed to make efforts to rid himself of inspired air He appears to pump the abdomen The condition of respiratory distress due to spasm of the diaphragm is recognized by the following points

1 The chest is expanded and in this condition may be fairly immobile
2 Breathing is regular in rate and rhythm
3 The patient can take in a breath and can hold his breath
4 There is no cyanosis
5 The patient has an exophthalmic appearance due to his efforts to exhale
6 The abdomen rises on exhalation a reversal of the usual movement
7 In the condition of pure diaphragmatic spasm the accessory muscles of respiration such as the sternomastoids and the pectorals do not usually attempt function and may in fact be alienated
8 A depression or groove on each side of the lower chest denotes the unusual pull of the attachment of the diaphragm which is in spasm (Figure 29a)

The patient with respiratory distress due to spasm of the diaphragm will usually recover The treatment of the condition is not completely satisfactory because of the inaccessibility of the involved structure Hot packs applied to the lower chest and to the adjacent abdomen appear to make the patient more comfortable and may be of some effect in relaxing the spasm of

the diaphragm Deflating the intestinal tract by the use of a rectal tube relieves some of the patient s distress The patient is usually most comfortable lying on his left side (Figure 29b) He is never placed in the prone position Raising of the head of the bed causes the abdominal viscera to gravitate away from the diaphragm and stimulation of the hyperirritable structure from this source is reduced

The patient with spasm of his diaphragm is in a condition of literally drowning in air The respirator having the effect of causing further expansion of the chest obviously could not relieve the patient and is in fact contra indicated

Paralysis of the Respiratory Muscles—The muscles responsible for respiration are skeletal muscles and as has been pointed out subject to all of the neuromuscular symptoms common to the disease of infantile paralysis Among these is paralysis due to injury or destruction of of the anterior horn cells of the spinal cord The muscles of respiration receive innervation from a considerable section of the spinal cord and paralysis of sufficient extent to seriously diminish respiration would indicate an overwhelming and probably fatal infection by the disease It is entirely possible that this does occur but such circumstances must be rare Where paralysis is the true condition responsible for the difficulty in respiration the use of the respirator would assist the patient in breathing

Patients have been observed to start with a paralysis first of the lower extremities but rapidly ascending to involve the trunk upper extremities and finally the respiratory system The patient is usually



Figure 29a Acute infantile paralysis Depressions over the lower ribs indicate the abnormal pull of the diaphragm in spasm in the condition of exhalatory distress

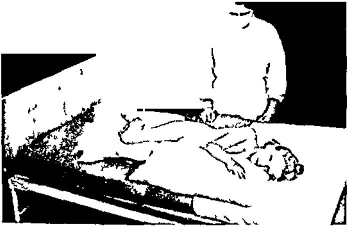


Figure 29b Acute infantile paralysis The position of comfort for the patient with diaphragmatic spasm Note the arm and leg supported by pillows

very ill and toxic and tends to lapse into unconsciousness, further indicating the seriousness of the infection. The mechanical respirator might be of service in prolonging oxygen exchange in this type of case but death usually ensues. Should such a patient survive, however, experience has shown that paralysis of the general musculature is apt to be extreme and very disabling. The use of the respirator further renders treatment of the condition of spasm of muscle impossible, with the result that added disability is imposed upon the patient because of contractures.

Restoration of Function and Coordination to the Breathing Mechanism

Breathing, accomplished by alternately expanding and contracting the thorax, is an action performed by opposing sets of respiratory muscles. Inspiration by expansion of the thorax is effected by contraction of the external intercostals and the diaphragm. Under stress the accessory muscles, particularly the sternomastoids and the pectorals, may assist inspiration. The opposite phase, that of expiration by contraction of the thorax, is largely a matter of the action of atmospheric pressure upon the expanded chest, but voluntary expiration is possible by contraction of the internal intercostals and the abdominal muscles. All of the disturbing neuromuscular symptoms characteristic of infantile paralysis may affect the respiratory system, that is, muscle spasm, mental alienation, incoordination, and paralysis may appear. Interference with breathing is particularly alarming to the patient. Particular attention must be paid the respiratory muscles, with the relief of spasm, to observe the presence of alienation



Figure 30a Restoring function and coordination to the respiratory system The inhalatory phase



Figure 30b The exhalatory phase

of certain muscles and the incoordination of action of other muscles The apprehensive excited patient frequently attempts breathing by incorrect muscle action adding to his distress as well as to the disturbance of his muscles He must be instructed in the proper respiratory rhythm by coordination of the opposing muscles Inspiration is taught by directing the mind of the patient to the area of the intercostales externi and requesting the patient to expand and raise the upper *anterior chest breathing in through his nose* Expiration then follows by the patient exhaling through his mouth, depressing and pulling the lower ribs down and *contracting the abdominal muscles for this phase It is* helpful for the attendant to touch lightly the upper chest for inspiration (Figure 30a) and to compress gently the lower ribs and indicate the recti of the abdominals for expiration (Figure 30b) This consists *essentially of a modified form of artificial respiration* for the patient and is done in bed for a few moments several times a day between the changing of packs The sternomastoid muscles must be observed for persistent contraction or attempted use and this condition discouraged by requesting the patient not to use these accessory muscles

MUSCLE STIMULATION

Beginning the Restoration of Nerve Pathways

As soon as the general condition of the patient permits and as the muscles in spasm become less irritable, immediate steps must be instituted to restore the disordered neuromuscular system to normal action Particularly of concern are those muscles which have become dissociated from the nervous system and appear paralyzed in that they are no longer under the control of the will Such muscles are alienated from the conscious voluntary mind and apparently also from the entire central motor system Mental alienation of muscle is a condition occurring in the acute stage of infantile paralysis due to a physiological depression or functional interruption of the motor pathway from the brain These non functioning muscles were once thought to be the paralyzed muscles but the anatomical nerve pathways are in reality not destroyed Such muscles are merely divorced from the voluntary motor center but will fail to resume function unless special steps are taken early to restore and maintain connection with the central nervous system The state of alienation in a muscle *appears to bear a distinct relationship to the* condition of the opposing muscle in that the opponent is usually a muscle in spasm The relief of acute muscle

spasm in the opponent is the first consideration in treating the condition of alienation When muscle spasm in the opponent has been sufficiently relieved as to allow a small range of passive motion in the joint, the next *step is to make use of all* available means to encourage muscle contractions in the individual non functioning muscles Great care must be used at all *times not to* excite the muscles which have been in spasm

The normal pathway to the conscious brain commences with specialized peripheral sense organs known as receptors These are many and varied but for our purpose consist of the cutaneous receptors in the skin and the proprioceptive receptors situated in the joints, tendons and muscles Information gathered from these sensory endings is transmitted by way of the afferent nerves to the spinal cord, then to the subconscious and finally to the conscious mind For instance, as a joint is moved, sensory impulses arise from the proprioceptive receptors which make this fact known to the nerve centers Immediately a response is invoked which reflexly directs impulses, by way of the efferent or *motor* pathway, for the muscles associated with the joint to *adjust themselves to the new* or changing position Certain muscles will contract to take up slack in order not to hang loosely Other muscles will elongate in order to allow motion of the joint The regulation of this mechanism is subconscious and, in fact, quite automatic However, the conscious mind is aware of *the change in* joint position and can *normally take steps either to* enforce *or to counteract* the change. It is this motor pathway from the brain, the restoration of which is sought after an attack of infantile paralysis and which must

be kept functionally open in order that voluntary muscular action will be resumed

The sensory or afferent pathway arising from the proprioceptive nerve endings in the joints, in the ten dons and in the muscles remains intact in the disease of infantile paralysis and conveniently furnishes us an avenue by which we may approach the subconscious and eventually the conscious mind in attempting to restore the normal volitional association between brain and muscle The motor or efferent half of the proprio ceptive reflex arc connected with certain muscles may be blocked in the disease of infantile paralysis and the corresponding muscles rendered non functioning or apparently paralyzed Such block is frequently purely physiological and the alienated muscles retrievable providing the motor nerve pathways can be induced to again carry impulses The procedure of muscle stimu lation offers this possibility

Usually by the third or fourth day of treatment in an acute case of infantile paralysis, muscle spasm has *been sufficiently relieved that a small range of passive* motion is possible in the corresponding joint Making use of this allowed range, it is possible to stimulate the alienated muscles which are usually the opponents of those in spasm, to resume tone or even to make sub conscious contractions The procedure entails the ex citing of the proprioceptive mechanism of the alienated muscle and tendon Providing the motor half of the proprioceptive reflex arc is anatomically intact, the tendon of the alienated muscle may become visible and sometimes stand out quite noticeably after stimulation Where there is a double insertion, such as in the ham-

strings, an endeavor should be made to produce equal tendons

Great care must be exercised *to observe the following* precautions

1. The opposing muscle in spasm must not be excited by producing tension in that muscle
2. The range of motion passively produced in the joint must take into account the normal functioning position of the muscle being stimulated according to the classification of that muscle as listed in Chapter VIII A given muscle which functions within a certain resting *length could not be stimulated to contract* if removed or stretched beyond that normal resting length On the other hand, muscles that contract normally only when elongated or removed beyond their normal resting length, must be so treated for the purpose of stimulation
3. *Normal alignment of the body and particularly* of the part being stimulated must be carefully observed
4. Only the joint associated with the tendon of the muscle being stimulated should be moved for any one procedure
5. The patient must be relaxed and is requested not to put forth any effort, either mental or physical, during the process of muscle stimulation He must think of nothing, thus conserving nervous energy The exciting of the proprioceptive muscle and tendon reflexes is carried on at a nervous level requiring neither the consciousness nor the volition of the patient His attempts would result in substitution of an adjacent muscle for the one alienated which would defeat the purpose of

stimulation The final result would be that of an undesirable state of incoordination

Muscle stimulation is conveniently done at the time of removal of the hot pack while preparations are being made for application of the next foment The joint should be passively put through a small range several times and the procedure may be done six or eight times daily The number and frequency of times that stimulation is done for any one muscle or group is variable and may be increased with the progress of the patient As the spasm subsides in the muscles opposed to those alienated a larger range of joint motion becomes possible and is utilized It is believed that a muscle normally receives it greatest impetus to contract when the muscle is at its full length In other words stimulation is most effective when performed by using the arc of joint motion nearest that of the neutral position of the joint with the body in normal alignment It must be kept in mind that the procedure induces lengthening and shortening of the alienated muscle within its normal range of function Stretching the muscle beyond its normal resting and functioning length would tend to discourage or further alienate the muscle under treatment unless of course the muscle under consideration is one which normally contracts when removed beyond its normal resting length

Muscle stimulation of any specific muscle or group is continued as a regular part of treatment until such time as voluntary control has become well established Subconscious control of muscle appears first This is evidenced by the fact that the muscle will be seen or felt to give a slight involuntary con

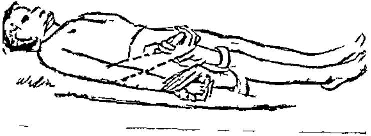


Figure 31 Stimulation of the elbow flexor muscles. The arc of motion used should not be great enough as to cause tension in the opposing extensors.

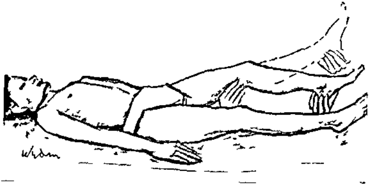


Figure 32 Stimulation of the quadriceps femoris. For the sake of illustration, the hip has been somewhat more flexed than would ordinarily be done especially when first beginning this procedure. The hamstring muscles, which are always in spasm must not be irritated by being placed on stretch.

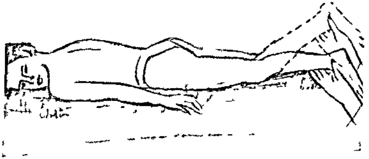


Figure 33 Stimulation of the hamstring muscles for knee flexion. The thigh is not raised from the table. In such muscle with a double insertion the attempt is made to stimulate both so that the tendons stand out equally.

traction during one of the periods of stimulation This may appear at the end of a few days or may not occur until several weeks have elapsed It is useless and of no avail to request a patient to make voluntary efforts at contraction of non functioning muscles until the subconscious control has been established Muscle stimulation is a procedure of great importance in re storing mental awareness of the alienated muscles and re establishing the normal brain pathways Examples of a few of the positions and maneuvers used are shown in Figures 31, 32 and 33

In the illustrations, the practice of muscle stimulation or the exciting of proprioceptive tendon and muscle reflexes is shown as carried out by passive movements of the joints In some instances this procedure can be more effectively accomplished by other means than by joint movements For example, to excite the reflexes of the extensors of the fingers and the toes, the attendant places her thumb upon the given tendon just proximal to the metacarpo phalangeal (or metatarso-phalangeal) joint and lightly depresses the tendon at the joint The part is held between the thumb and index finger of the attendant and the tendon is depressed several times in quick succession before pro ceeding to the next finger (or toe) This procedure has the same effect as the regular method of stimulation in that an excitement is caused in the area Impulses arise in the tendon which are carried by means of the sensory or afferent nerve route to the motor center Providing the center is structurally intact, impulses are then relayed over the motor or efferent half of the route to the muscle Once this reflex cir-

cuit is functionally re established, the subconscious mind will be excited to cause a contraction in the muscle and alienation is thus defeated Eventually the conscious mind resumes control and restoration of active function is obtained

In Figure 33, the method of stimulating the hamstrings by joint movement is depicted This procedure is sometimes ineffective owing to the difficulty of causing excitement of the peripheral receptors at the tendinous attachments Therefore, if alienation is persistent and restoration and contraction of the hamstrings cannot be quickly obtained by joint movements, further procedures to cause an excitement in the area of the tendinous attachments must be employed The origins of the long toe extensors are situated in the region of the insertions of the hamstrings and these toe muscles may be utilized to produce an excitement to stimulate the hamstrings The outer hamstring or biceps is particularly often very difficult to stimulate and assistance can frequently be given With the knee of the patient slightly flexed, the attendant stimulates the toe extensors by passively flexing the fourth and fifth toes several times in quick succession After doing this the tendon of the biceps may be palpated as a tiny structure and this may be improved by then putting the knee joint through a small range of movement several times passively For the medial hamstrings, the medial toes can be similarly utilized Great care must be exercised not to overstress these activities Immediately that the tendon is perceptible, stimulation must cease until the same procedures are repeated at the next session Particularly must the patient not be requested to attempt contraction of the hamstrings or to flex the knee as this

may interrupt the reflex activities obtained by the procedures described

The necessity of keeping the part in normal align ment during the process of stimulation cannot be overemphasized Consider the head and neck for example In the art of stimulating the sternomastoids, it must always be kept in mind that to successfully accomplish this the opposing muscle groups must be relaxed and the head must be in normal alignment If the chin is elevated, it must follow that the rectus capitis posterior major and minor must be in contraction to have ac complished this and therefore the sternomastoids can not be stimulated to contract The contraction of the posterior group alienates the anterior group If the attendant attempts to stimulate the sternomastoids with the chin of the patient elevated, the procedure will fail to accomplish its aim and the effort is doomed to failure

Muscle stimulation is carried out daily for all muscles which are alienated or non functioning The proce dure is obviously of no value and is discontinued after conscious active function of the specific muscles has been restored

PART II

THE CONVALESCENT STAGE

THE NEUROMUSCULAR SYSTEM

Introduction to Re education

THE neuromuscular system consisting of the brain, spinal cord peripheral nerves and skeletal muscles constitutes a complex but efficient mechanism designed primarily for motility as well as for maintenance of body posture Motor impulses arising within the central nervous structure are transmitted to the muscles over the common peripheral pathway of nerve fibers projecting from the anterior horn cells of the spinal cord These impulses are considerably developed and modified by various auxiliary parts of the nervous system so that the final expression of nervous energy is that of smooth coordinated muscular activity While the entire system is complex and intricate, motion is largely controlled by three functional nervous levels

1 Conscious or voluntary
2 Subconscious
3 Reflex

Each of these levels has its particular function in directing motor activity in the normal subject yet none is completely independent

Dominating the entire motor system is the conscious or voluntary center located in the cerebral cortex which exerts a guiding and at the same time an inhibi

tory control over the lower and less highly organized centers Smooth coordinated muscular operation is dependent upon the intact voluntary motor center and spinal tracts, as witness the perverted and sometimes riotous activity which takes place in the cerebrospastic patient when loss of cortical control places the manage ment of muscular action upon the lower motor cen ters While there is no proof that the brain cortex itself suffers any particular organic damage to essential structures in infantile paralysis, yet the common occur rence of incoordination in practically all untreated cases of the disease is evidence of a disorganization at some point in the pathways between the brain and the muscles Quite unconsciously such patients attempt to produce a motion by simultaneously contracting muscle groups opposed to each other or even by contracting muscles totally unrelated to the part For instance, the untreated patient frequently contracts the quadriceps when requested to dorsiflex the foot and another fa miliar example is to see the patient contract the trape zius when intending to abduct the arm The untreated case displays many such examples of misdirection of nerve impulses Where there is functional interruption of the motor pathway with alienation or where there is actual loss of anatomical continuity with paralysis the conscious voluntary center is frequently no longer able to effect habitual and highly selective motor acts and, being unable to obtain response in specific mus cles the conscious voluntary center tends to lose aware ness of those muscles In such case the patient volunta rily substitutes some adjacent muscle for the one which is weak or non functioning but this procedure again en courages incoordination Since the actual motor centers

of the conscious mind and the coordinating mechanism are not considered to have been destroyed in infantile paralysis, there is no particular reason why coordination cannot be restored with proper measures of re-education.

Contractile function as it is resumed in alienated muscles occurs first in the subconscious level of the mind. Involuntary and sporadic contractions of muscle are observed by the attendant who is conducting re-education long before the patient's mind is conscious of the returning ability to perform voluntary action. It would therefore seem logical in attempting to restore function and coordination to the disturbed neuromuscular apparatus that the approach should be made at the more accessible or subconscious level. Once control of muscle and coordination of muscle action is secured in the subconscious mind a similar state can be induced in the more highly integrated conscious voluntary level and the full brain path restored.

The proposal to re-educate or to restore useful function to the neuromuscular system after disorganization by a disease such as infantile paralysis necessarily implies possession of an intimate anatomical knowledge of the individual muscles of the body and their duties, but more than that it requires an exact understanding of the action and synchronization of muscles and of the motor control by which they are directed in harmonious and effective function.

Too little study has so far been made of the differences in behavior and action of the various individual muscles of the body. Critical observation of the functional anatomy of muscles discloses differences which are of vital importance in attempting to

restore action to disabled muscles Consider, for example, the upper extremity with the elbow joint in its neutral extended position The biceps muscle is ready to contract from the normal resting muscle length The triceps, however, is unable to contract from this position because it is already in its shortest condition and must be lengthened by flexing the elbow before it can be induced to give a contraction In other words, the triceps is a muscle which must be removed from its normal resting length before contraction occurs

Some muscles, such as the sternomastoids, have more than one origin and therefore more than one action A single muscle may have the ability to pull from either of its bony attachments or have effect upon more than one joint Certain muscles are merely stabilizers of joint positions attained by other muscles It is obvious that such vital information must be determined about every principal muscle of the body before any rational scheme of reorganization can be applied to the disordered mechanism after an attack of infantile paralysis So essential is this knowledge that the following chapter will be devoted entirely to the subject

Each muscle of the body has a definite primary action in producing motion, which is obviously the result of the most direct pull of that muscle upon its bony attachment, and the principal muscle is the prime mover of the concerned joint in the given direction In general, the more fixed attachment of a muscle is spoken of as the origin while the more movable part to which the muscle tendon runs is known as the insertion Knowing the motions of which a joint

is capable, the relationship of the muscle to the joint and the attachments of the muscle, one may deduce the exact action of a prime mover

A muscle, in contracting normally, pulls from its tendinous insertion folding in a smooth graduated manner towards its origin The origin serves merely as an anchoring point for the muscle This characteristic behavior may in some cases, as in infantile paralysis, be reversed the muscle attempting to pull from its origin, but when such action is without purpose it must be considered as a disturbance of coordination within the muscle Restoration of proper function in this case depends upon the redirection of the nerve impulse to the muscle fibers in order that the muscle may effectively pull from its tendinous insertion to perform the required action Disalignment of a joint, as may occur in infantile paralysis disturbs the position of muscles, their resting lengths and direction of pull, which discourages and in some cases actually prevents an otherwise normal muscle from contracting Such malposition of a joint must be relieved before the associated muscles can be expected to resume proper action

Muscles are in functional balance, that is, that for each motion produced by a muscle action there is an exactly opposite motion capable of performance by an opposing muscle This equilibrium is not established on the basis of muscle strength The gastrocnemius, for instance, will always exceed the opposing tibialis anterior in power Standing walking, running or jumping will call for varying degrees of effort on the part of the gastrocnemius in plantar flexion of the foot yet in no instance has the tibialis anterior to do more than dorsiflex the foot The effective motions of a joint

depend upon the orderly *regulation of the opposing* muscles by the nervous system When, for instance, the flexor of a joint begins to contract, the extensor must *simultaneously either* elongate or actively relax paying out slack in a graduated manner so that smooth motion of the joint results The relaxing muscle must at all times retain a certain amount of tonus so as to be able to contract *instantaneously and reverse the* joint motion

The harmonious action of opposing muscles in producing orderly joint motion is spoken of as coordination The smooth, orderly and effective functioning of muscles is a matter of automatic control by the directing centers in the central nervous system *The exact position of a joint and the state of relaxa*tion or contraction of the associated muscles is made continuously known to the regulating motor centers by proprioceptive impulses conveyed from the joint tendons and muscles Appropriate impulses are returned to the joint and its acting muscles according to the information gleaned from these proprioceptive stimuli

When a principal muscle ceases to function from whatever cause and the brain connection regulating the *specific motion is lost contiguous muscles are comman*deered by the will of the patient to take over the work of the non functioning muscle in attempting to perform the given motion by a stronger contraction of *the most* accessible or adjacent muscular elements This is commonly recognized as substitution The control of motion is a complex affair dominated by a conscious *selective motor* center in the cerebral cortex Man by virtue of his ability to voluntarily select and con

trol muscle action, immediately attempts to place an extremity in such position that the substituted muscle will function to its best mechanical advantage In so doing the resulting change in joint position must considerably disturb the reciprocal action and coordination of all muscles involved in the specific joint motion Proprioceptive impulses relayed to the centers of control would be confusing to say the least when originating from a joint which is no longer in normal functioning position.

From the foregoing discussion, it is obvious that free and uncontrolled movements can have no place in the re education of the neuromuscular system following an attack of infantile paralysis To allow and encourage a patient in the free choice and substitution of muscles for the mere satisfaction of haphazard joint motion is to establish improper and ineffective patterns of neuromuscular activity and to invite permanent confusion of muscle action The resulting disturbance of coordination may become almost as disabling as paralysis itself Every mental and physical effort of the patient, from the beginning of treatment, must be guided and controlled Only by so doing can an undesirable state of muscle incoordination be avoided and mentally alienated muscles be restored to function Re education of, or restoration of proper function to alienated muscles is only possible after coordination has been re-established in all contracting muscles concerned with the part A muscle, whether paralyzed or alienated, which is being trained must be made to contract at least in a mental sense if in no other way The conscious mind must be made aware of the muscles and must visualize contraction of the non functioning mus-

cle when the joint is moved in order that orderly and coordinate action of the muscle and its opponent will ensue To accomplish this result the patient must be accurately instructed in the location of muscles and particularly in the insertions of the muscles He must understand the resultant action of the joint and parts when the insertion of a muscle is pulled upon by the contraction of the muscle The direction of motion of a joint must always accurately correspond with the principal action of the muscle which is being trained and the limb must be in a position which is as normal for the human body as possible.

In summary then the person who essays to re educate the neuromuscular system after an attack of infantile paralysis must be in possession of certain fundamental knowledge of muscle anatomy and muscle function The direct application of this knowledge from the very beginning of the symptoms of the disease is necessary in order to prevent the establishment of muscle incoordination and permanent mental alienation of muscles Only after the complete relief of muscle spasm and thereby keeping all muscles soft long flexible and receptive can the principles of muscle re education be employed On beginning movement absolute control by the attendant of the motion being taught must be demanded at all times in order to direct nerve impulses properly back to the non functioning muscle and to prevent substitution and incoordination Under no circumstance must the patient be allowed any attempt at voluntary movement of a part where incoordination of muscle action is present Voluntary contraction of a muscle can be allowed only after the subconscious and conscious mind have re

accepted the proper rhythmic action of the muscles involved in the joint motion The tendency for mis direction of nerve impulses to muscles not concerned in the specific joint motion must be prohibited in order that the exact nerve pathways to the muscles being trained can be restored and made permanent Re education of or restoration of function to muscles after infantile paralysis depends then upon the relief of spasm upon the teaching of mental awareness of muscles the combating of incoordination and the re training of nerve pathways back to the non functioning muscles Meticulous adherence to these principles and the beginning of treatment with the onset of the symp toms of the disease will prevent stiffness and deformi ties will preserve all tissues in an excellent state of nutrition and will reduce to a minimum the crippling after effects of the disease

5

MUSCLE FUNCTION

Classification, Type, Action and Synchronization of Muscles

BEFORE undertaking to restore function to the dis turbed neuromuscular system after an attack of infantile paralysis, a thorough understanding of the action of muscles according to classification, type and syn chronization is imperative in addition to a knowledge of the anatomical origin and insertion of each prin cipal muscle The important fact that all muscles do not normally perform in an exactly similar manner has not been clearly reported by the physiologists Lack of detailed information regarding muscle action has made it difficult in the past to bring about a satisfactory return of muscle function in patients suffering from the disease of infantile paralysis Intensive study and further research will be necessary before the subject can be fully elaborated The presentation here, al though incomplete, is essential and will be helpful in the execution of the work known as muscle re-educa tion

CLASSIFICATION OF MUSCLES

According to the functioning length from which muscles normally undertake contraction, the skeletal muscles may be listed in two major classifications

[illegible]

[illegible] more than

[illegible] in previous

[illegible]

A muscle with tendinous origin as well as tendinous insertion usually has the ability to pull from either end to produce separate actions The psoas, for example, pulling from its tendinous insertion flexes the thigh upon the pelvis but pulling from its tendinous origin it flexes the pelvis upon the thigh Not only is such information necessary for the restoration of mere action to the muscle but it is also important in restoring proper and rhythmic contraction of the fibers composing the muscle A muscle with tendinous origin and tendinous insertion, for instance, may, from disorganization of the nerve pathway after infantile paralysis, incoordinately pull from the wrong end for the desired action and will require re direction of the nerve impulse to restore proper function to the muscle

Consideration of Muscle Classification

Classification I—Muscles that contract within their normal resting length to produce an action

The serious consequences in lessening the value of a muscle by allowing or encouraging the muscle to accommodate itself to a newer and shorter resting length between its points of origin and insertion has already been discussed in Chapter I The further importance of understanding the functional nature of muscles coming within this classification is to comprehend the deleterious effect upon the potential action of such muscles when they are removed from their normal resting length Such a muscle when removed or pulled beyond its normal resting length will be inhibited from giving a normal forceful contraction and may lose power altogether from this cause A typical

Classification I—Muscles that contract within their normal resting length

Classification II—Muscles that have to be re moved from their normal resting length before a suitable contraction can occur to perform their primary action

TYPES OF MUSCLES

Consideration of the potential action of muscles according to their anatomical construction discloses that the muscles may be listed under four major de scriptive types

Type A—Muscle with single origin single in sertion and with either single or multiple action

Type B—Muscle group with separate origin common insertion and with multiple action

Type C—Muscle group with dual origin dual insertion and with multiple action

Type D—Muscle or group that stabilizes a posi tion obtained by other muscle groups

It is also obvious and important from the standpoint of re education that the nature of the origin and inser tion of a muscle determines the potential functional ability of that muscle The simple muscle with a single fibrous origin and a single tendinous insertion usually is capable of but a single action which is the result of contraction of the muscle from the tendinous insertion A muscle with two origins however is usually capable of producing more than one action and these must be secured in restoring the muscle to proper function The *sternocleidomastoid* for example arising from the sternum and from the clavicle has the double action of flexing the head forward and of rotating the head

A muscle with tendinous origin as well as tendinous insertion usually has the ability to pull from either end to produce separate actions The psoas, for example, pulling from its tendinous insertion flexes the thigh upon the pelvis but pulling from its tendinous origin it flexes the pelvis upon the thigh Not only is such information necessary for the restoration of mere action to the muscle but it is also important in restoring proper and rhythmic contraction of the fibers composing the muscle A muscle with tendinous origin and tendinous insertion, for instance, may, from disorganization of the nerve pathway after infantile paralysis, incoordinately pull from the wrong end for the desired action and will require re direction of the nerve impulse to restore proper function to the muscle

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Classification I —Muscles that contract within their normal resting length to produce an action

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example is that of the abdominal muscles which contract within their normal resting length to assist flexion of the trunk in the supine person Should the posterior spinal muscles be in a state of spasm causing lordosis *the abdominal muscles being persistently pulled beyond* their normal resting length will be unable to put forth an effective effort and would *in the past have been* adjudged as weak or paralyzed The abdominal muscles *in this case are not paralyzed but tend to become* alienated It will be impossible to obtain an effective effort from the abdominal muscles until they are restored to their normal resting position Actually the abdominal muscles are almost never paralyzed but may be restored to useful function after the release of spasm in the affected posterior spinal muscles Requesting a muscle of this classification to attempt any contraction outside or beyond its normal resting length is likely to cause incoordination

The highly important procedure of stimulation of muscles belonging to Classification I must always be carried out within the normal resting length and range *of action* of such a muscle To remove such a muscle from this position during the process of stimulation is *to diminish the possibility* of evoking response because of the abnormal position and hence the procedure defeats the *object of treatment*

The principal muscles in Classification I will be taken up in the order of the regions of the body

Neck—The anterior groups responsible for flexion of the head are those of the sternomastoid muscles The extensors of the head (rectus capitis posterior major and minor) are of Classification II When the head is being supported in cor

rect alignment these opposing groups of muscles are both within their respective normal resting lengths Should the head be pulled backward the sternomastoids would be removed from their normal resting length and would be unable to give a contraction to return the head to the normal alignment The platysma muscle being of Classification II having been removed from its normal resting length by the elevation of the chin will contract to restore the chin to its correct alignment and the sternomastoids are then again able to effectively perform having been returned to their normal resting length

Shoulder Region —The upper trapezii are of Classification I muscles contracting within their normal resting length

The rhomboids are also of Classification I

Upper Limb —The deltoid muscle is in its position of normal resting length when the extremity is at the side of the body It is impossible to stretch the deltoid and the traditional procedure in the past of placing the arms in abduction to relax these muscles is illogical except when the deltoid itself is in acute spasm When the deltoid appears to have lost the power of contraction it will usually be observed that the opposing adductor muscles are affected by the condition of spasm Placing the upper extremity in abduction will have a serious effect upon the shoulder adductors (pectoralis major and latissimus dorsi) resulting in disorganization of the action of these muscles and causing incoordination

The principal muscles of the upper limb belonging to Classification I muscles that contract within their normal resting length are

Deltoid
Subscapularis

Teres minor, Infraspinatus
Coracobrachialis
Biceps brachii
Brachialis
Brachioradialis
Pronator teres
Wrist flexors (flexor carpi radialis, flexor carpi ulnaris)
Finger flexors (flexor digitorum profundus, flexor digitorum sublimis)
Lumbricals

Trunk—The principal muscles of the trunk which contract within their normal resting length are

Intercostals
Abdominals
Iliocostalis lumborum (when working alone)
Quadratus lumborum

These muscles of the trunk, in their action, all have an important inter relationship with each other The abdominal muscles contract to assist in flexing the trunk when the patient is in the supine position, and this action is accompanied by contraction of the intercostales interni The intercostales externi, although the fibers merge over the lower ribs with those of the obliquus externus, are really opponents to the abdominal muscles and the action of one is accompanied by relaxation of the other Thus, if there is interference with exhalation and the ribs are not easily depressed the abdominal muscles will experience difficulty in putting forth an effort since they are being persistently pulled beyond their normal resting length The iliocostalis lumborum by virtue of its attachments is able to fix or depress the ribs Because of these attachments, spasm of the iliocostales lumborum may place a serious restriction upon the patient's

respiration in not allowing expansion of the rib cage for inhalation

Lower Limb—The principal muscles of the lower limb contracting within their normal resting length are

- Abductors of the thigh (gluteus medius and gluteus minimus)
- Iliopsoas
- Internal rotators of the thigh
- Tensor fasciæ latæ
- Hamstring groups (biceps femoris, semitendinosus, semimembranosus)
- Gluteus maximus in its major action (i e, stabilization of the lower extremity upon the pelvis)
- Tibialis anterior
- Peroneus tertius
- Peroneus longus
- Calf muscles (gastrocnemius and soleus)
- Flexors of the toes

The psoas major is worthy of mention in that both its origin and its insertion are tendinous in character, hence the one muscle is endowed with the property of pulling from either end to produce different motions The psoas arises by a series of small tendinous arches from the lumbar vertebræ and has its insertion by means of a narrow tendon to the trochanter minor femoris Pulling from the small tendinous arches at the origin the muscle will assist in bending the body forward, pulling from its long tendinous insertion it will assist in flexing the thigh For both these motions, the psoas contracts within its normal resting length It is possible to use either motion or both together for the purpose of stimulating the muscle

It may appear that some of the muscles discussed

in Classification I actually are capable of contracting *when removed beyond their normal resting length* Such a contraction is never a normal action but is usually *an action requiring an extraordinary effort* in which the entire muscle contracts as a unit A muscle when contracting *normally within its resting* length, folds in a smooth graduated manner beginning at the tendinous junction To repeatedly request the effort of contraction from a muscle of this classification when removed beyond its normal resting length will result in improper action of the individual muscle and will encourage the establishment of incoordination in the muscles of the region

Classification II—Muscles in Classification II are those which must be removed from their normal resting length before a satisfactory contraction can occur to produce a useful action

The serious restriction placed upon the action of the opponent in allowing a muscle to become permanently shortened refers especially to muscles coming within this classification Too much stress cannot be placed upon the importance of understanding the functional activity of muscles belonging to this classification The important procedure of stimulation of *muscles belonging to Classification II* can only be successfully accomplished by removing such *muscle beyond its* normal resting length Such a muscle normally receives its impetus to contract *for the performance* of motion only when it has been elongated beyond its normal resting *length* *To place* the body or any particular part of the body in a position during *the acute or convalescent* stage of the disease so that the

Classification II muscles of that part are continuously removed from their normal resting length causes such muscles to receive stimuli for contraction but when they are at the same time prevented from performing a normal useful action the result is a disorganization of function and the establishment of incoordination A typical example is that of the adductors of the shoulder the pectoralis major and the latissimus dorsi muscles If the upper extremity is placed and held in abduction a disarrangement of the normal functioning of the shoulder will result The fact that the maintenance of the limb in a position of abduction defeats the effort of attempted restoration of the limb to a neutral position does not prevent the attempt but the adductors will have been changed mentally to abductors and will endeavor to contract and assist in abduction On seeking the restoration of the movement of abduction the effort of the abductors will be very much hampered by the incoordinated activity of the adductors in attempting to assist the opponent

The principal muscles of the body belonging to Classification II that is muscles that have to be removed from their normal resting length before a suitable contraction can occur to perform their primary action will be listed

Neck

- Platysma
- Rectus capitis posterior major and minor

Trunk

- Pectoralis major
- Latissimus dorsi
- Sacrospinalis (full group)

Upper Limb
- Triceps
- Forearm supinators
- Wrist extensors (extensor carpi radialis longus extensor carpi radialis brevis, extensor carpi ulnaris)
- Finger extensors

Lower Limb
- Adductors of the thigh (adductor brevis adductor longus, adductor magnus)
- External rotators of the thigh
- Quadriceps femoris
- Tibialis posterior
- Peroneus brevis
- Toe extensors

Consideration of Muscle Type

Depending upon anatomical construction, a muscle or a muscle group may be capable of one or more actions A knowledge of the normal abilities of the principal muscles is a prerequisite to the successful re education of the neuromuscular system It is necessary to have a clear conception of the muscle action being sought as well as to be able to recognize an incorrect action

Type A —Muscles with single origin, single insertion and with either single or multiple action

This is the simplest type of muscle and from the standpoint of the principal action of an individual muscle is the most common The brachialis, arising by fibrous origin from the lower half of the front of the shaft of the humerus and crossing the hinge of the elbow joint to insert

into the coronoid process of the ulna, is an example of a muscle capable of but a single action It is usual for a muscle of this type to have a single primary action but such muscles commonly have functions which are accessory to the principal action The tibialis anterior, for example, has a principal action of dorsiflexing the foot, but it is capable also of elevating the inner border and of inverting the foot

Type B—Muscle group with separate origin, common insertion and with multiple action

Neck Sternocleidomastoids

Each muscle group has its origin by two heads, the medial head arising by a long tendon from the manubrium sterni and the lateral head arising by a short tendon from the upper surface of the sternal extremity of the clavicle These two portions unite at about the middle of the neck and the group inserts by a short tendon to the processus mastoideus Each muscle has a dual action in pulling from the mastoid attachment The muscle of one side acting alone turns the head to the opposite side and the face upward at the same time Acting in conjunction with the muscle group of the opposite side, the muscle flexes the head forward and downward With the head fixed, the two sternocleidomastoid muscles elevate the clavicles and the sternum (and with them also the thorax) This latter action must be kept in mind as the muscles may perform incoordinately after an attack of infantile paralysis, thus elevating the chest by pulling from the origins rather than pull-

Upper Limb
- Triceps
- Forearm supinators
- *Wrist extensors* (extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris)
- Finger extensors

Lower Limb
- Adductors of the thigh (adductor brevis, ad ductor longus, adductor magnus)
- External rotators of the thigh
- Quadriceps femoris
- Tibialis posterior
- Peroneus brevis
- Toe extensors

CONSIDERATION OF MUSCLE TYPE

Depending upon anatomical construction, a muscle or a muscle group may be capable of one or more actions A knowledge of the normal abilities of the principal muscles is a prerequisite to the successful re education of the neuromuscular system It is necessary to have a clear conception of the muscle action being sought as well as to be able to recognize an incorrect action

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the group entering into any specified effort If the gastrocnemius group is working in equal con traction and the heel retained in perfect align ment neither supinated by spasm in the medial head nor abducted by spasm in the lateral head and correct re education is given foot deformities do not occur however badly paralyzed the anterior or the posterior group may be

Type C —Muscle group with separate origin dual insertion and with multiple action

Lower Limb Quadriceps femoris Hamstrings
The importance of recognizing this type of mus cle is that close observation must be made to see that each part of the group puts forth an equal effort in the performance of a given movement If allowed one portion may attempt to contract sep arately with the result that the other portions of the group tend to lose power or become alienated Disalignment of a joint or allowing the limb to lie persistently in a position which does not con form to normal al gnment may favor one por tion of a group and cause unequal contraction in the component portions of the muscle group For instance a valgus condition of the knee as may be caused by a shortening of the ilio tibial band favors the vastus lateralis of the quadriceps group The lower extremity lying in external ro tation favors the biceps femoris of the hamstring group Equalizing the strength in both parts of a group which performs a common action will avoid certain deformities If the inner hamstrings are not encouraged to retain equal strength and equal resting length with the outer the tibia will drop medially and the disturbance of the gravitational force upon the ankle will cause the condition of flat foot to appear

ing from the insertions at the *mastoid processes to flex the head* In this case, the muscles would be considered as weak unless the true state of inco ordinated action of the muscles was perceived and rectified

Upper Limb Deltoid

This group has its origin in three heads, fleshy from the clavicle and from the acromion process and tendinous from the spine of the scapula Its insertion is by one common tendon into the deltoid tubercle of the humerus The structure of the *group is complex and really consists of three dis* tinguishable portions, an anterior, a middle and a posterior portion The muscle has multiple actions depending upon the portion or portions entering into any specified movement The middle portion lifts the upper arm lateralward in the shoulder joint The anterior portion draws the arm for ward and rolls it inward The posterior portion draws the arm backward and rolls it outward The *various combinations of the portions* produce ac tions which are the result of the component forces exerted by the muscle portions participating

Lower Limb Triceps surae

The calf group arises from three heads consisting of the soleus and the medial and lateral heads of the gastrocnemius The insertion of the group is by a common tendon, the tendon of Achilles into the calcaneus The group is capable of multiple action principally of plantar flexion of the foot but also of adduction and abduction of the heel, depending upon the component parts of

Iliocostales lumborum

The iliocostales lumborum stabilizes the spine in the upright position when a person is walking

Quadratus lumborum

The quadratus lumborum stabilizes the pelvis and trunk in the lateral plane

Lower Extremity Tensor fasciæ latæ

The tensor fasciæ latæ muscle has its origin by a tendinous band from the external lip of the iliac crest The fiber bundles pass distally to become incorporated with the tractus iliotibialis which inserts into the tibia The muscle therefore has action upon two joints and is a stabilizer of the entire lower extremity upon the pelvis

MUSCLE SETTING

The exercise known as muscle setting which has been widely advocated and which is in vogue in many clinics must be mentioned for the purpose of condemnation in the treatment of infantile paralysis This has been defined as "an action of contracting the muscles without moving the part to which the muscle is attached through even a partial arc of joint motion The setting of the quadriceps with the knee in extension is clearly shown by the upward movement of the patella "* That this procedure is both illogical and damaging is obvious considering that contraction of the quadriceps is being brought about within the normal resting length of the muscle whereas the quadriceps is a muscle which must be removed from its normal resting length before a satisfactory contraction can occur

*United States Public Health Bulletin No 242 1939 page 15

Type D—Muscle or group that stabilizes a position obtained by other muscle groups

Most stabilizers contract within their normal resting length and bind or stabilize the group that has brought the skeleton into position

Shoulder Region Latissimus dorsi

The latissimus dorsi stabilizes the inferior angle of the scapula and allows the teres major to extend the upper limb Failure to insure stabilization of the scapula will allow the condition of winged scapula to be brought about

Trunk Gluteus maximus

The gluteus maximus muscle stabilizes the thigh in extension after it has been brought into this position by the hamstrings The gluteus maximus muscle has been usually accepted as the extensor of the thigh This is a mechanical impossibility The contraction of any muscle is a gradual shortening or contraction from the point of attachment until the full muscle fibers are closed and held in the condition of contraction right up to the origin of the muscle The fact that the gluteus maximus muscle lies in an oblique position from its origin to its insertion and the fibers run nearly parallel lateralward and downward to pass over into the deep layer of the tractus iliotibialis, in addition to the fact that the muscle contracts within its normal resting length, would lead to the conclusion according to mechanical law that the action of this muscle is

1 To stabilize the thigh when extended
2 To prevent the inward rotation of the femur while the thigh is in extension

muscles of the region is encouraged by the procedure of muscle setting The muscle mistakenly expends its energy contracting without producing movement It is very difficult to set a muscle without contracting its opponent, otherwise motion of the joint will occur Teaching a patient to contract opposing muscles simultaneously will result in incoordinated and ineffective muscular action when the restoration of rhythmic movement is later sought

Synchronization of Muscle Action

Motility does not consist of isolated and exclusive muscular contractions but rather of synchronous action of groups coordinated into a harmonious whole It is necessary to consider and make detailed study of the cooperative and sympathetic action of muscles and groups which function to produce useful and effective activity All re-educational exercises should be given only after acquiring familiarity with all sympathetic muscle action and after careful study of bodily mechanics Great care must be exercised to encourage the restoration of synchronous and coordinated muscle function as soon as possible after starting treatment

Restoration of normal function to the neuromuscular system requires the adoption of all measures to insure perfect harmony of all muscles of the body, having in mind the utility and functional activity of the parts as well as the whole organism In considering the act of walking, for instance, the psoas and the hamstrings work together, the psoas supporting the thigh and the hamstrings supporting the leg Therefore, in restoring function to this region, once the

to produce a useful action Contraction of the quadriceps within the normal resting length of the muscle is likely to promote the deformity of hyper extension of the knee The normal action of this group in contracting is to extend the knee or lift the leg forward when the knee is flexed and the muscle group stretched from its normal resting length *If contraction is attempted,* as in the procedure of muscle setting the muscle group *will attempt to lift the leg forward from the already* extended position and thus will force the head of the tibia backward so that the deformity mentioned above will be promoted

A further harmful effect in teaching a patient muscle *setting is that the procedure fosters ineffective* action and mental alienation of the muscles so treated in any part of the body The patient s mind is alienated from the correct point of attachment of the muscle Contraction of the quadriceps within the normal resting length of the muscle transfers the point of insertion to a position just above the patella in the thought of the patient instead of to the normal insertion at the tibial tubercle Patients who have been taught setting of the *quadriceps are frequent*ly observed to be able to pull upon the patella yet be unable to exert any effort in attempting to extend the flexed knee Pulling from a point above the patella and producing no motion at the knee impresses the patient that power is lacking in the muscle The result is that the quadriceps becomes mentally alienated *and the patient attempts to produce the desired* movement by other means

Incoordination both within *the muscle and in the*

PRINCIPLES OF TREATMENT

Practical Considerations in the Restoration of Function of the Neuromuscular System

THE ultimate object of treatment of the disease of infantile paralysis is to restore rhythmic, coordinated, useful muscle function to the disturbed neuromuscular system From the standpoint of therapy it is hardly possible to divide the disease into acute and convalescent stages While the main object in the acute stage is that of the relief of muscle spasm by means of the application of hot foments, yet the attempt to restore the physiological continuity of the nerve pathways back to the muscles must engage the attention at the earliest possible moment The re education of the neuromuscular system must begin in the period immediately following the subsidence of acute symptoms and be developed and carried forward without interruption through convalescence to the ultimate conclusion or recovery of the case There is really no such thing as a mild case of infantile paralysis The term non paralytic does not connote that the patient is non affected or even less that recovery from the disease will occur spontaneously Contractures and deformities are frequently observed to appear in such cases during the early period of recovery or later where the muscle

brain path is re established to the muscles, care is exercised that synchronous action is taught the psoas and the hamstrings As a step is taken the quadri ceps are lengthened from their normal resting length and the glutei are relaxed The action of the quad riceps is to restore itself to its normal resting place and to extend the knee while the gluteus maximus working in unison, is returned to its normal resting place and contracts so that the body is stabilized or supported in the upright position

Similar consideration must be given to all movements of the body In coming up to the sitting position from the supine position, for instance, there is a definite se quence in the order of contraction of the muscles in volved in the motion The platysma depresses the chin, the sterno mastoids then flex the head, the *intercostales interni* contract while the abdominals begin flexion of the trunk, finally the psoas comes into action to flex the pelvis and the movement of sitting up is completed

The brain path and the correct action must first be restored to the individual groups but there must finally be synchronization of the individual parts concerned in all bodily movements before normal coordinated func tions can be considered to have been re established If this is properly done there will be no awkwardness of gait or necessity for trick motions but rather will move ment be smooth and rhythmic as nature intended *This is not a matter of muscle strength but of the restoration of synchronization of muscle action*

sion in the muscle in spasm nor should any muscle in spasm be encouraged to perform contraction as these events have a damaging effect upon the sensitive muscle tissue If passive motions are painful or arouse fear in the mind of the patient re education procedures in any form are not only impossible but any attempts will have the effect of defeating the object of treatment The handling of the patient should always be so gentle that pain is never caused as this arouses fear in the mind of the patient and defeats efforts to get his cooperation The patient continues to be confined quietly in bed throughout the length of the period of contagion and until such time as muscle spasm has been sufficiently relieved that further steps in restoration of muscle function can be instituted Usually by the third or fourth week the patient can be moved to the treatment table This is determined by the fact that active spasm has been relieved There will still be some tightness in muscles but they are no longer sensitive or hyper irritable and slight stretch does not evoke a reaction of either acute pain or spasmodic contraction

Every patient will require training after an attack of infantile paralysis as every patient will have suffered at least a disorganization of the motor pathways with incoordination The patient does not spontaneously recover from this condition and it is disabling unless corrected Where there are muscles which have lost function and are alienated or apparently paralyzed the problem is more difficult It is useless to request a patient to attempt voluntary contraction of the non functioning muscles as control must be acquired first in the subconscious centers This is brought about

condition of spasm has not been attended at the onset Every patient will have muscle spasm which will demand treatment if the avoidance of deformities is to be assured In those patients who have apparent paralysis, the condition of alienation may be the sole cause of or at least contributes to the non function of muscle and needlessly increases the amount of permanent paralysis unless proper procedures are carried out to restore function to these muscles Every patient will exhibit the damaging condition of incoordination of muscle action unless proper retraining of the neuromuscular system is carried out

In approaching the treatment of the disease, the first step in the acute stage is that of analysis of the muscle conditions and determination of muscles in spasm, largely through inspection and observation as outlined in Chapter II Whether or not there are muscles which have lost function is of no immediate concern at this time and the attempt to determine muscle power is forbidden Muscle testing in the acute stage gives no information of any value and will cause further spasm to be excited, as well as promote the development of incoordinate muscle action Usually after three or four days of treatment by hot foments the spasm will have sufficiently relaxed as to allow a small range of passive motion in the joints At this time it is possible to obtain information as to the presence of alienation in the muscles opposed to those in spasm and to begin the first careful steps in the restoration of function to these alienated muscles by stimulation of their proprioceptive nerve endings as outlined in Chapter VI Under no consideration should any joint motion be carried out to such extent as to cause ten-

(b) that no muscle involuntarily attempts to perform the main action of another muscle
(c) that opposing muscles do not contract simultaneously in attempting to perform a given joint motion
(d) that there be no substitution of a strong muscle for a weaker one

Coordination is first established in the sub voluntary motor centers by the process of passive movements of the joints, making use of the proprioceptive mechanism as in muscle stimulation No voluntary effort is allowed the patient in the presence of incoordination of muscle activity Substitution of muscles must never be allowed as this will encourage incoordination

3 *Restoration of MUSCLE FUNCTION* Resumption of proper voluntary control of muscle represents the successful re establishment of the normal physiological activity of the motor mechanism The object of all treatment is to restore useful effective action to the neuromuscular system Awareness of muscles having been taught incoordination having been combatted and coordination restored the culmination of re education is achieved in conscious voluntary muscular action Ultimately, with continued training, this is sustained rhythmic, effective and purposeful

During the daily treatment period, the patient is moved to the treatment room where he is secluded with the technician Complete and undivided attention of the patient is necessary for success He is placed upon a well constructed and solid table (Figure 34), which gives him a feeling of security and allows him to relax Complete general relaxation is necessary in order that the mental effort of the patient

by the process of muscle stimulation as explained in Chapter VI Re education and restoration of proper activity of the neuromuscular system after an attack of infantile paralysis is based upon three *essential considerations*

1 *Restoration of MENTAL AWARENESS of muscles* This is the procedure of restoring consciousness of muscles and particularly of teaching the patient the projection of thought to the specific insertion of muscles in order that the brain path can be re established and neural impulses properly directed A muscle normally begins contracting from the tendinous insertion The patient must acquire the ability to visualize this point of attachment and the effect upon the limb when the muscle pulls from this point so that he can mentally follow the movement which is at first performed passively for him No physical effort is encouraged or allowed to be directed to the affected part until awareness of all muscles of the part is thoroughly re established in the patient's consciousness and there is coordinated action of the fibers comprising the specific muscles as well as coordination of all acting muscles of the region

2 *Restoration of COORDINATION or combatting of incoordination* This procedure is really an exercise for the nervous system as the regulation of coordination is a function of the motor centers It is carried out in conjunction with the teaching of mental awareness of muscles The combatting of incoordination depends upon observing

(a) that the individual muscle being trained contracts beginning with the fibers at the insertion where motion is sought and progresses rhythmically toward the origin

can be directed entirely to the part being treated Requesting the patient to take a deep breath and then to sigh will encourage relaxation All re education is carried out from two basic positions prone or supine with the arms at the sides in conformity with the principle of always maintaining correct body alignment (Figures 35 and 36) No exertion is required to maintain these postures and therefore the nervous energy and entire mental effort of the patient can be directed to the procedures being carried out The first treatment periods should be short so as not to fatigue the patient In beginning the treatment period it is usual to start with the part of the body most severely affected in order to secure the maximum mental effort while the patient is fresh If attention should flag during the session it is best to discontinue the treatment for the time being If possible each time the patient should be left with a sense of achievement and a desire to continue his efforts at the next session on the following day A cheerful and optimistic attitude should be encouraged at all times

EXAMPLE OF THE RE EDUCATION PROCESS

For each part of the body treated the technician must herself be in possession of certain fundamental knowledge as to the normal action and synchronization of the regional muscles in order that she can successfully utilize the appropriate technique in training the patient This is especially true in those patients exhibiting muscles which are non functioning where *the greatest training and skill is required* in the means of restoring impulse to the muscles

Consider the anterior neck muscles for example

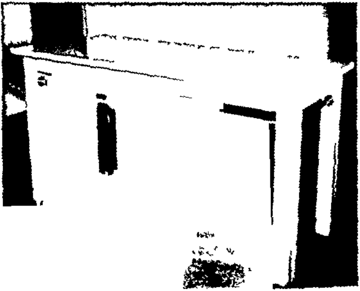


Figure 34 Standard Treatment Table
Specifications length 6 feet
height 3 feet
width 2 feet and 6 inches

can be directed entirely to the part being treated Requesting the patient to take a deep breath and then to sigh will encourage relaxation All re education is carried out from two basic positions, prone or supine, with the arms at the sides, in conformity with the principle of always maintaining correct body alignment (Figures 35 and 36) No exertion is required to maintain these postures and therefore the nervous energy and entire mental effort of the patient can be directed to the procedures being carried out The first treatment periods should be short so as not to fatigue the patient In beginning the treatment period it is usual to start with the part of the body most severely affected in order to secure the maximum mental effort while the patient is fresh If attention should flag during the session it is best to discontinue the treatment for the time being If possible each time the patient should be left with a sense of achievement and a desire to continue his efforts at the next session on the following day A cheerful and optimistic attitude should be encouraged at all times

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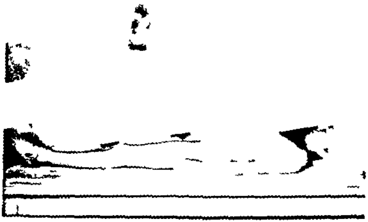
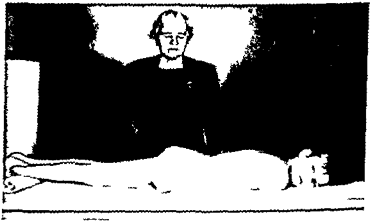


Figure 35 The sup ne posit on of the patient for the re education procedures on the treatment table



F gure 36 The prone pos tion of the pat ent on the treatment table *All re education exercises are carr ed out from these normal prone and sup ne pos tions*

which are frequently alienated or apparently paralyzed as a result of spasm in the opposing posterior neck muscles The mere release of spasm in the posterior neck muscles does not effect spontaneous resumption of function in the anterior neck muscles On the contrary, the patient will attempt to substitute other muscles with resulting improper action and incoordination and the sternomastoids will remain alienated and non functioning until proper steps are instituted to restore them to function Contemplation of the sternomastoid muscle according to its classification and type brings out four important points

(a) The muscle is of Classification I and contracts within its normal resting length Therefore, in attempting to restore function, it is necessary to work within the range of normal resting length of the muscle, starting from the position of full resting length

(b) The muscle is of type B, having two heads It is important that contraction occur in both portions when function is resumed by the muscle

(c) The muscle has two actions in moving the head, that of forward flexion and that of rotation Both of these movements may be utilized in attempting to restore impulse to the muscle

(d) The muscle, in contracting, has the ability normally to pull from either end The attendant *is interested only in restoring its* action in moving the head, and is therefore careful to eliminate the other action of assisting the raising of the chest in respiration

Early in the course of training, when the muscle exhibits no evidence of voluntary contraction, the treatment for these muscles consists entirely of tendon and muscle stimulation to contact the motor centers, and other procedures with passive movements designed to restore mental awareness of the muscle and encourage coordinate action of the fibers of the sternomastoids as well as of all the muscles of the region In a single treatment period at this early stage, the treatment for the sternomastoids would consist of the following procedures Exact instruction regarding grips and the other pertinent details will be found in the chapter on Restoration of Function to Muscles of the Neck

1 *Muscle Stimulation*

From the position of normal alignment and with proper grip, the head is forward flexed several times by the technician for the purpose of stimulation of both the sternomastoids The head is then rotated to each side several times, simultaneously elevating the chin, for the purpose of stimulating the sternomastoids individually The patient exerts no mental or physical effort and is directed to think of nothing concerning the neck during these movements The purpose of this procedure is to re-establish connection with the subconscious motor centers, making use of the proprioceptive nervous reflex mechanism Stimulation is no longer done after conscious voluntary control of the muscle has been established

2 *Guided Passive Movements*

Without altering the position of the patient and with maintenance of the proper grip, the technician directs the attention of the patient to the points of attachment of the [illegible]astoid muscles to the [illegible]d processes [illegible] passively for-

ward flexes the head of the patient The patient is instructed that the movement results from the contraction of the muscles beginning at the sterno mastoid processes The patient mentally follows the movement of forward flexion of the head but exerts no physical effort The patient is re directed to concentrate upon the points of attachment of the muscles before beginning each motion and to mentally follow each movement as it is guided and carried out by the technician Three passive movements are given at the session The individual movements in the rotation of the head are also each carried out three times The patient exerts no physical effort during the entire procedure The technician observes carefully that no involuntary actions occur in any of the regional muscles If these are present the patient is not in a state of relaxation and is not properly concentrating upon the muscle being trained Complete mental and physical relaxation of the entire body must be secured before continuing with the treatment The patient must place himself unreservedly in the hands of the attendant The purpose of the procedures described is to re train the brain path to the insertions of the sternomastoid muscles and to restore awareness of these muscles as well as coordination to all the neck muscles

3 *Guided Assisted Active Movements*

After several days or weeks the technician perceives that there is beginning subconscious control of the sternomastoid muscles This is evidenced usually by the fact that the muscle gives a sudden involuntary contraction during stimulation or passive movement The patient may also be requested to put forth a physical effort every few days for the purpose of determining whether or not there is connection with the conscious centers If the connection has been made the patient is then ready to

attempt active contraction and resume conscious control of the muscle. After the second passive movement, the patient is requested to put forth physical effort to forward flex the head. If this is successfully achieved, the patient performs the third movement actively after two passive movements at each subsequent treatment period but always with the assistance and guidance of the technician. Care must be exercised that both the sternal and clavicular portions of the muscle are contracting. As control becomes more permanently established, the patient makes the second and finally all three movements actively but always with guidance by the attendant. At any time that incoordinate action is perceived, such as attempts to pull from the lower attachment of the muscle or attempts to contract the platysma, active movements are stopped and passive movements resumed until such time as coordinated action of the sternomastoids is restored as well as proper action of all regional muscles.

The same procedures are carried out for all portions of the body according to the classification type and synchronization of the muscles for the part being trained, and the complete treatment is done during each training period. Movements which are done actively by the patient are assisted early and later resisted by the attendant. All movements are guided and controlled by the attendant until full voluntary function is established in the part being treated. *Needless to say, no massage is ever used during any part of the course of treatment.*

It is essential that correct body alignment be insisted upon during the entire treatment period as well as during the interval between treatment periods. Certain

muscles will obviously be in various phases of restora tion in the same patient and the treatment accorded each part will be according to the stage of recovery Throughout the entire course of re education all move ments are guided and directed by the technician until full coordinated action to the entire body is restored The final object is not that of trained individual mus cles or parts of the body but rather a coordinated whole which performs normal actions with graceful rhythm

GRIPS

The importance of the position of the technician s hands on the body of the patient in physical therapy cannot be overestimated This contact may be util ized to advantage in re establishing connection between the patient s mind and the more peripheral parts of his body Improper use of the hands may be detri mental and even defeat the objective of treatment The hands must be so placed as to serve as a guide for any effort to be put forth by the patient and at the same time to convey to the technician any action attempted or achieved by the patient The hands of the technician must support the part in normal align ment and direct motion accurately according to normal function In the chapters to follow on restoration of function of muscles of various parts of the body, the illustrations will show the advantage taken by the technician in the use of the palm of the hand or one or more of the fingers to guide both the brain path and the physical efforts of the patient These grips must be carefully studied and followed exactly

Take the head for example It will be noticed in

Figure 38, with the patient in the supine position, that the head is resting completely and quietly on the hands of the attendant The thumb of the attendant is on the mastoid process in order to train the brain path of the patient to the insertion of the sternomastoid muscle at this point The idea is to establish in the mind of the patient the exact spot where contraction of the muscle must start in order to flex the head forward as *the sternomastoids contract and the posterior muscles* relax

The grips used *in restoration of function of muscles* of the limbs must be especially carefully studied On no account must the hand of the technician be placed *on the belly of a muscle which is contracting or for* which a contraction is sought Wherever contact is registered, the patient directs his brain path to the point of contact instead of to the point from which *contraction should normally commence This results* in an incoordinate contraction within the muscle, and attempts by the technician to secure a normal contraction beginning at the tendon are thus defeated On no account must any part of the hand of the technician come in contact with the tendon of a muscle, the contraction of which is undesired in the movement being performed It *will* be noticed, *for* example, in Figures 62 and 63 that in the grip used in *guiding the movement of flexion of the* thigh the fingers of the attendant do not come in contact with the insertion of the tendon of the sartorius muscle The sartorius frequently incoordinately attempts to flex the thigh in place of the psoas Directing the brain path of the patient to the tendon of the sartorius *by grasping* the leg at this point encourages the undesirable efforts

of the sartorius to attempt hip flexion and thus blocks the directing of impulses to the psoas Similar careful observance must be carried out for every portion of the body which is being trained The illustrations in the succeeding chapters will be of assistance in learning the proper grips and positions of the hands The technician must be on the alert that the placing of her hands never interferes with muscle action

SITTING UP

The patient is not allowed to sit up as long as active spasm is present or where shortened muscles pull the body into disalignment in the sitting posture As soon as there has been accomplished a good return of function to the muscles of the trunk and these muscles are of fair strength the patient may be allowed to sit up for graduated periods up to one half hour The restoration of function to muscles of the trunk is extremely important and deserves the particularly careful attention of the technician Patients who are able to stabilize the trunk well in the upright position will be likely to succeed in walking even where there is considerable weakness of the extremities Where the muscles of the trunk are functioning the posture in sitting up will help to restore coordination and strength to these muscles With increasing strength the patient may be allowed more time sitting up but this time should be limited to not more than two daily periods of one half hour each during the major part of the course of treatment

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STANDING

It will be recalled that an important procedure carried out during the recumbancy of the patient in bed is that of firm pressure of the soles of the feet against a solid upright footboard The purpose is to stimulate the normal standing reflexes of the patient It is obvious that the position of recumbancy modifies the value of this procedure somewhat and it is therefore necessary to consider the value of the standing posture for the effect of stimulating the postural muscles As soon as spasm and tightness have been largely relieved and providing there has been fairly good return of function and strength to the trunk muscles, the patient may be stood upon his feet for a few moments following the daily treatment period The technician should steady the patient by the hands Where the trunk muscles are able to stabilize the trunk upright, there is little tension placed upon the muscles of the extremities in standing as this is more a matter of balance rather than of the exertion of muscle power

WALKING

Because of the great variability of the conditions occuring in different patients it is practically impossible to generalize about the procedure of walking This is not allowed early in the disease and certainly never where there is active spasm or any incoordination Walking is a complex action requiring the cooperation of muscles of many parts of the body It is important that every effort be made to restore the trunk muscles to good control before allowing walking, as an ability to stabilize the trunk is essential Coordination of muscles

concerned with the individual parts is first taught and then rhythmic cooperation of the whole The technician must carefully observe that the stabilizing muscles of the trunk perform properly and that there is no attempt to substitute muscles in the extremities or to move the limbs in any but the normal motions Assistance should be given at first and later some patients may require crutches for walking Crutches are of a special type having a circular band at the top and they do not extend above the elbow (Figure 37) This type of crutch aids the patient in balancing but gives a minimum amount of support from the upper extremities They therefore help to direct the attention and concentration of the patient to the lower part of the body The amount of walking must be carefully graduated in order not to tire the patient Once coordination and rhythm is well established the careful patient will walk himself back into greater muscle strength

As soon as the patient is able to walk satisfactorily he may become an outpatient and return daily or thrice weekly to the clinic for treatment It is important that the ambulatory patient continue to have long periods of rest at home Activities unnatural to human movements such as swimming and bicycling are to be avoided It is generally wise that a child not be subjected to the stress and activities of school until a year has passed after his acute infection

THE INFANT

It is obvious that the procedures outlined require the active cooperation of the patient and are hardly applicable to the young child under two years of age The young patient although requiring a different tech

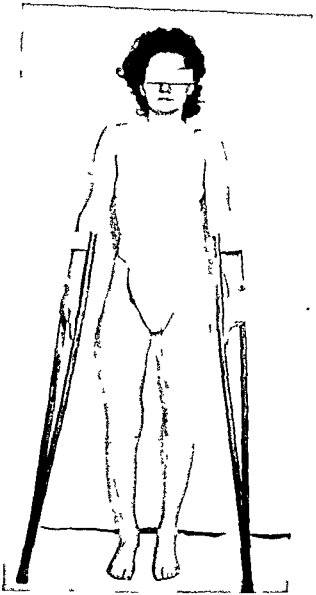


Figure 37 The type of crutch used for walking The patient pictured has complete paralysis of the left lower extremity and partial paralysis of the right lower extremity yet she walks well without braces Note the absence of deformities

nique, can be trained without great difficulty providing he is always treated by one and only one technician The infant has developed little selective control of muscles and is therefore not likely to develop substitution and incoordination The technician must see that the child is relaxed and not resistant Soothing words and a little play usually accomplish this Training is then largely a matter of conditioning the child s mind Certain words are chosen to be used for each specific movement and are always spoken when the technician carries out the given movement Gradually these motions become active in response to the spoken word The infant tires readily The treatment period should not be of such length that the child becomes fretful otherwise he will resist subsequent attempts at treatment Usually only part of the body is done at one period and another part on the following day The patient should be left with a desire to continue the pleasant experience on the next occasion of treatment No great harm will result from the sporadic attempts of the infant to stand up in his crib but this is not to be encouraged

RESTORATION OF FUNCTION

Muscles of the Neck

WHEN the neck muscles are affected in a patient suffering from infantile paralysis, great care must be taken to see that the spinal vertebræ in this portion of the body are kept in perfect alignment, both during exercises and in the interval between exercises To ac complish this, an air ring is blown up sufficiently to allow the back of the head to rest lightly upon the bed The convexity of the cranium is placed within the ring This procedure will prevent the chin from dropping downward and prevent contraction of the platysma which sometimes causes difficulty in swallowing If the head is placed upon a pillow, the chin will be forced downward because the head rests upon the flatness of the occiput The same thing applies when the patient is placed upon the bed without a pillow but to a lesser extent The head supported within the ring allows the convexity of the cranium to be the resting point rather than the flatness of the occiput below the convexity If the platysma is in spasm, the sides of the mouth will be drawn downward This spasm must be released as soon as possible by the proper application of hot packs

THE ANTERIOR GROUP

The muscles principally used to bring the head for ward and downward are the sternomastoids These

muscles belong to Classification I, that is, of muscles contracting within their normal resting length and of Type B, muscle groups with separate origin, common insertion and with multiple action The actions of the sternomastoids are

1 To bring the head forward and downward when working in unison
2 The muscle of one side acts alone to turn the head to the opposite side and the face upward

The muscle groups of each side must pull equally from their points of insertion on the sternomastoid processes to produce a rhythmic movement For the purpose of restoration of function to the sternomastoid muscles, the patient is placed upon the table in a supine position The shoulders reach to the edge of the treat ment table (Figure 38, page 196) If the patient is placed with the head upon the treatment table, the con vexity of the cranium will force the head forward and downward and it will be impossible to obtain a satisfac tory contraction of this muscle owing to the fact that the head is already forward and downward The head is supported by the hands of the attendant The thumbs of the attendant are placed on the mastoid processes of the patient to direct the mind of the patient to these points of attachment of the sternomastoid muscles from which contraction must commence The spine is kept in perfect alignment The attendant then proceeds to restore

1 *Mental awareness of the part*
2 *Coordinated action*
3 *Muscle contraction or function*

Mental Awareness —The patient is requested to relax and allow the attendant to support his head entirely The patient is then told that it is the intention of the attendant to bring the forehead forward and downward, explaining that this movement is accomplished by the pull of the sternomastoids from their points of insertion (processus mastoideus) The forehead of the patient is touched lightly by the attendant in order that he may better visualize the beginning forward movement which is to take place and to insure that the patient will not merely pull the head downward to the chest when active contraction of the muscles is resumed The attendant must see that the movement commences with the contraction of the sternomastoids from the insertion Any suggestion to the patient of bringing the chin toward the chest must be avoided as this will result in a spasmodic but ineffective effort in which the muscle improperly contracts as a single unit from both ends The patient is requested to follow the movement mentally but is told not to make any physical effort The movement described above is performed passively three times by the attendant without any physical effort on the part of the patient If it is felt that the patient can put forth a physical effort, he is allowed to make the attempt after two passive movements have been given The third is the active movement on the part of the patient

Coordination —This third movement should be closely scrutinized by the attendant to observe if a coordinate action is taking place, that is, an equal contraction of the muscles of each side, proper contraction of each muscle from the point of insertion and no action from any other muscle group The attendant will observe if the action is coordinate by the following details

muscles belong to Classification
contracting within their normal
Type B, muscle groups with
insertion and with multiple
sternomastoids are

1. To bring the h
   when working
2. The muscle
   the head to
   upward

The muscle group
from their points o
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restore

1
2
3

flexion of the head by active contraction of the sternomastoid muscles This is done after two passive movements by the attendant, i e, three movements in all All movements are carefully guided and assisted by the attendant The active movements are graded upward to three at each session as power returns, i e, from three passive to two passive with one active, then to one passive with two active movements and finally three active movements These are always with the assistance and guidance of the attendant until full voluntary control has been re-established

The second action of the sternomastoid group, as already stated, is to turn the head to the opposite side and the face upward when the muscle of one side functions individually The same general procedure is adopted to achieve this action as was described in the preceding section when the full group received attention The patient remains in the supine position upon the treatment table as before, the attendant supporting the head in the same manner The attendant then endeavors to restore mental awareness by focusing the mind of the patient on the point of attachment (processus mastoideus, left or right) The head is then rotated to the side desired by the attendant and the muscle shortened between the insertion (processus mastoideus) and its double origin (both the sternal and clavicular portions should contract on active motion) If the muscle of one side is not contracting satisfactorily, it must be observed whether a spasm is present in the opposite sternomastoid or whether spasm is present in the posterior group, that is, in the trapezius Spasm of the sternomastoid of one side will prevent any attempt at contraction on the opposite side because of fear of

1 Equal contraction of both sternomastoids will result in equal pressure transmitted to the hands of the attendant and the head will be forward flexed in midline If a greater pres sure is observed on either the right or the left hand of the attendant, the attendant will know that a greater effort has been put forth to promote a contraction in the side where the greater pressure is felt If the contraction is unequal, the patient is encouraged to put the mental ef fort to the weaker portion of the group while the attendant focuses the mental awareness to the point of attachment of the weaker side, that is, to the right or left processus mastoideus Spasm of the neck muscles, either anterior or posterior, may also cause an unequal contrac tion If spasm is present, proper treatment must be applied for this condition

2 The fibers of the individual group must contract properly beginning from the point of insertion A misdirected impulse may result in an incoordinate contraction beginning from the origin of the muscle at the chest Such a con traction would be ineffective in forward flexing the head as it would be noticed that the patient attempts to bring the chest up toward the chin

3 On no account whatever, is the patient allowed to draw the corners of the mouth down ward and bring the platysma into action

If at any time an incoordinate action is ob served, the patient is immediately requested to re lax all physical effort and only passive movements are used at the session until coordination is defi nitely established

Muscle Function —If it is felt that awareness and coordination have been properly restored, the patient is requested to perform the movement of

pain The side on which the spasm is present may falsely give the appearance of contracting satisfactorily but if the true condition of spasm is not recognized and properly treated a contracture of this muscle will result and the patient will develop a permanent torticollis Immediate steps must be taken to reduce the spasm in order to allow both sides to perform the desired action rhythmically

THE POSTERIOR GROUP

In order to attend this group satisfactorily, the patient is placed in the prone position upon the treatment table The shoulders are supported at the edge of the table as before and the head is supported by the hands of the attendant (Figure 39) If the rhomboids are affected, the shoulders are supported on pads so as to bring the scapulæ to the midline alignment The feet are supported in a resting position The toes of the feet are kept off the surface of the table by means of a pad or piece of sponge rubber placed under the tarsus and ankle (Figure 39) The spine is kept in perfect alignment The attendant proceeds then to restore mental awareness, coordination and muscle function to the posterior group The principal muscles exercised are the rectus capitis posterior major and the rectus capitis posterior minor The action of these muscles is to draw the head backward at the atlas

> *Mental Awareness*—To restore awareness, the patient is requested to relax and to mentally concentrate upon the movement performed by the attendant in bringing the head backward toward the spine The passive movement is carried out by the attendant three times at one treatment session



Figure 38 The supine position for the restoration of function to the anterior neck group *The thumbs of the attendant are used to indicate* to the patient the points of attachment of the sternomastoid muscles at the mastoid processes

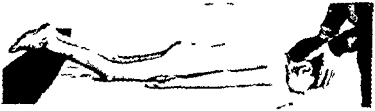


Figure 39 The prone position of the patient and the grip of the attendant for the restoration of function to the posterior neck muscles

The Trapezius

The upper trapezius assists in drawing the head backward when the shoulder blades are fixed, therefore, a spasm in this muscle would also prevent the forward movement of the head This receives attention if the condition is present Besides the action of drawing the head backward, the upper trapezius of one side acting alone bends the neck toward the same side To restore function to the trapezius, the following procedure is adopted While the patient is still in the prone position as seen in Figure 39, the attendant proceeds to restore

1 *Mental awareness*

2 *Coordination*

3 *Muscle function to this muscle (upper trapezius)*

The attendant stands at the head of the treatment table supporting the head of the patient with both hands (taking care that the spine is in perfect alignment)

Mental Awareness —The patient is requested to mentally visualize the action of drawing the head backward while the attendant performs the action passively This movement is carried out three times at one treatment session From the position with the head in normal alignment the attendant next moves the head from right to left and vice versa while the patient mentally follows this movement The lateral motions are also carried out passively *three times at the same session*

Coordination —The attendant sees that this movement is carried out only by the muscle group

Coordination—The attendant must carefully observe that no muscle groups are contracting *other than the posterior neck muscles* The sterno mastoids must be particularly observed that they are not attempting the action of extension of the head The attendant must see that both sides are contracting equally If one side is in spasm and is preventing the other side from contracting the spasm must again be treated No active or volun tary contraction is allowed until proper coordina *tion has been definitely established*

Muscle Function—When the brain path and coordination have been restored the patient is al lowed to make one active movement at the end of the session i e after two passive movements All movements must be carefully guided and as sisted by the attendant If at any time incoordi *nate actions occur the patient is requested to re* lax all physical effort and only passive movements are carried out at the treatment session until co ordination has been established The movements allotted to the patient are gradually increased un til all three are performed actively The attendant guides and assists all movements until full volun tary control by the patient has been re established

The posterior group is very frequently affected by spasm which tends to draw the head backward and prevent the forward flexion of the head The back ward movement of the head is much more easily ac complished under these conditions than the forward although both are painful in the acute stage of the disease *A spasm in this group will* cause the patient to present the appearance of fear and induce an at tempt at general immobilization of the body

cause painful spasm does not allow the relaxation of the rectus capitis posterior major and minor and the harmonious contraction of the sternomastoids It has been argued that this was the result of meningeal irritation However, this condition of stiffness has been observed in cases where the spinal fluid was normal and gave no indication of any inflammatory process

In reference to this condition of rigidity through spasm it is interesting to note that spasm in the gastrocnemius causing muscle rigidity will prevent dorsiflexion of the foot, spasm in the quadriceps will prevent flexion of the leg spasm in the hamstrings will prevent flexion of the thigh and extension of the leg at the knee, and spasm in the posterior spinal muscles will prevent flexion of the trunk It is only reasonable to expect that spasm in the posterior neck muscles will also cause rigidity and prevent flexion of the head This is apparently the natural outcome of the condition of spasm wherever it exists and is persistent It is easy to conceive and understand how this rigidity caused by spasm would prevent any effective contraction in the opposing group and consequently give the examiner the impression that the opposing muscle group is paralyzed when this latter group has really not in any way been affected by the disease proper Such muscles opposed to those in spasm frequently become alienated but are nevertheless, apt to become truly paralyzed and atrophy from disuse unless the true conditions are recognized and rectified

Spasm in the posterior neck muscles will prevent the *supine patient from lifting his head and this will give* the examiner the impression that the sternomastoid muscles are weak or paralyzed When the spasm in the

under observation and that no other group attempts to assist The anterior group must not be allowed to contract The *sternomastoids* are *not* allowed to contract but must rest within their normal resting length otherwise *incoordination will* be established

Muscle Function —When it is determined that mental awareness and coordination have been established the patient is requested to make one active movement after the two passive ones, i e, three movements in all As control by the patient becomes more firmly established the movements allotted to the patient are gradually increased until all three are performed actively All *movements are guided and assisted by the attendant* until full voluntary control by the patient has been re established

COMMENTARY

The first natural movement of the human being when he attempts to bring the body from the supine position to an upright posture is the forward flexion of the head The chin is maintained in position by the platysma while the sternomastoids bring the head forward The abdominals then contract to bring the trunk forward and finally the psoas contracts to flex the pelvis and bring the body to the sitting position The anterior muscles which flex the head, trunk and pelvis forward all belong to Classification I, muscles that contract within their normal resting length therefore, the action of these muscles is adversely affected when they are removed from their normal resting length or when function is prevented by the condition of spasm in the posterior muscles It has been found in some cases that the act of sitting up is impossible be

cause painful spasm does not allow the relaxation of the rectus capitis posterior major and minor and the harmonious contraction of the sternomastoids It has been argued that this was the result of meningeal irritation However, this condition of stiffness has been observed in cases where the spinal fluid was normal and gave no indication of any inflammatory process

In reference to this condition of rigidity through spasm, it is interesting to note that spasm in the gastrocnemius causing muscle rigidity will prevent dorsiflexion of the foot spasm in the quadriceps will prevent flexion of the leg spasm in the hamstrings will prevent flexion of the thigh and extension of the leg at the knee, and spasm in the posterior spinal muscles will prevent flexion of the trunk It is only reasonable to expect that spasm in the posterior neck muscles will also cause rigidity and prevent flexion of the head This is apparently the natural outcome of the condition of spasm wherever it exists and is persistent It is easy to conceive and understand how this rigidity caused by spasm would prevent any effective contraction in the opposing group and consequently give the examiner the impression that the opposing muscle group is paralyzed when this latter group has really not in any way been affected by the disease proper Such muscles opposed to those in spasm frequently become alienated but are nevertheless, apt to become truly paralyzed and atrophy from disuse unless the true conditions are recognized and rectified

Spasm in the posterior neck muscles will prevent the supine patient from lifting his head and this will give the examiner the impression that the sternomastoid muscles are weak or paralyzed When the spasm in the

posterior muscle group has been slightly relaxed and the patient is able to raise his head a little from the bed, but *will not attempt to flex his trunk*, the examiner might deduce that the abdominal muscles were weak and he would in the past have applied a support to these muscles To determine whether the inability of the patient to sit up is due to weakness of the abdominals or to the involuntary shortening of the posterior neck and spinal muscles the following test is applied

> The patient is partially set up and an acute angle made between the trunk and the lower extremities by raising the legs from the table (*The lower extremities must have been unaffected or have recovered*) The patient is requested to support the legs and maintain the described position If this is possible, the abdominal muscles are good and it may safely be assumed that the affected muscles are those of the posterior neck The condition of spasm or involuntary shortening of the posterior neck muscles can generally be detected by the presence of an exaggerated sulcus or groove extending from the base of the skull (Figure 1)

RESTORATION OF FUNCTION

Muscles of the Shoulder

The muscles of the shoulder girdle region are very apt to suffer from contraction through spasm and serious loss of function results if the condition is unrecognized A keen lookout must be kept for any occurrence or recurrence of this muscle condition and immediate steps must be taken to combat the spasm Also special care must be exercised to see that all muscles are kept at the full length of their normal resting place No shortening of any muscle should on any account be encouraged by allowing or placing the extremity in any position outside that of normal alignment To obtain the desired result in re education of the muscle groups the attendant proceeds to restore as soon as possible

1 *Mental awareness*
2 *Coordination*
3 *Muscle function*

TRAPEZIUS (upper)

The principal action sought for the upper trapezius is that of elevation of the shoulder upward The patient is placed supine upon the table (Figure 40)

Mental Awareness.—The attendant stands beside the table on the affected side of the patient and proceeds to restore first, mental awareness of the affected muscle group. The neural impulse must travel the brain path to the point of attachment of the muscle group from which a contraction is desired. In order to achieve this the patient must mentally concentrate upon this point *(spine of the scapula) to the exclusion of all* other effort. The patient is watched to see that *the body as a whole is completely relaxed*. The attendant grasps the upper arm just below the point of attachment of the deltoid (Figure 40) in order to support the weight of the limb. The attendant then lifts the shoulder upward passively while the patient mentally follows the movement. Three passive movements are done in all.

Coordination.—The attendant observes closely whether a contraction is occurring in any muscle group other than the one receiving treatment. ... the
involuntary
the patient
then directed to concentrate upon the action being performed by the attendant.

Muscle Function.—When it is felt that mental awareness and coordination have been restored, the patient is allowed to do the movement actively, acting under the guidance of the attendant after the two passive movements have been made. The active movements allowed the patient are gradually increased, i.e., to one passive with two active and finally all three active movements. The attendant supports the limb and controls all movements.

Besides the upper trapezius, the *levator scapulæ* also

tient so that the shoulder girdle will be immobilized and not raised when the arm is abducted The attendant requests the patient to visualize the point of attachment of the deltoid (tuberositas deltoidea humeri) and mentally follow the movement of abduction which is performed passively by the attendant

When the attendant has passively brought the limb to the position of abduction, the patient is requested to relax mentally and to transfer his mental effort to the points of attachment of the pectoralis major and the latissimus dorsi on the arm and the patient is then informed that these muscles will contract and bring the arm back to the side The patient mentally follows the movement of adduction but makes no physical effort The passive movements are carried out three times during the session

Coordination —The attendant must take particular care to see that no contraction occurs in any other muscle of the body during the exercise for abduction Especially is the upper trapezius to be noted as the patient commonly contracts this muscle and elevates the shoulder This results in a division of the nerve impulse so that full effort is not applied to the deltoid and incoordination results The patient is instructed to relax all effort and to let the shoulder drop When it is certain that there is complete relaxation without contraction in the trapezius the attention is directed to the deltoid The shoulder adductors are also to be carefully noted for any incoordinate attempts to assist the movement of abduction

When the movement is reversed and the arm is adducted to the body, the attendant must carefully observe that contraction does not occur in any other muscles than the adductors (pectoralis

major and latissimus dorsi) which are being trained

Muscle Function.—When it is found that a physical effort can be made by the patient, the attendant will request the patient to perform the movements actively, starting from one active movement after the two passive ones of each session and grading upward to three active guided movements. The limb is supported by the attendant and all movements are guided until full voluntary control has been acquired by the patient.

Should there be any spasm of the biceps brachii, the shortening of this muscle would interfere with the movement of abduction. In this case the elbow is flexed to relax the biceps during the exercises for the abductors and adductors of the shoulder (Figure 42).

FLEXION OF THE UPPER EXTREMITY

The principal muscle performing flexion of the arm is the coracobrachialis. The patient maintains the supine position on the table. The attendant stands at the side of the table (Figure 43) and proceeds to restore mental awareness, coordination and function to the muscle.

Mental Awareness ... patient is requested to direct his mind to t... of ... coracobrachialis ... humeri and to ... the ... fl... while the ... ely ... and ... is ... it is ... is ... in



Figure 42 The position for the restoration of function to the abductors and the adductors of the upper extremity when involuntary shortening of the biceps brachii restricts the movements of the position shown in Figure 41



Figure 43 The position and grip for flexion of the upper extremity (coracobrachialis muscle)

relax all mental effort and the arm is returned passively to the side of the patient by the attendant

Coordination — The attendant watches very carefully to see that no contraction occurs in any other muscle, particularly the pectoralis major

Muscle Function —When it is felt that the brain path and coordination have been restored, the patient is allowed to make one active movement, i e, two passive movements and one active for the session As power returns the movements are graded upward to three active ones The attendant assists and guides the movements until full voluntary control by the patient has been re established

INTERNAL AND EXTERNAL ROTATION OF THE UPPER EXTREMITY

The principal muscle responsible for the movement of internal rotation at the shoulder from the neutral position is the subscapularis The principal muscles concerned with external rotation from the neutral position are the teres minor and the infraspinatus These muscles all insert upon the humerus at its upper end

The neutral position of the arm is the point midway between internal and external rotation It will be noted in Figure 44 that the arm has been completely externally rotated before beginning the movement of internal rotation In this position the subscapularis has been removed beyond its normal resting length and is, therefore, unable to contract satisfactorily The pectoralis major rotates the arm to the neutral position and full internal rotation is then carried out by the subscapularis A similar situation holds for the movement of external

rotation with the group of muscles concerned with that movement

In the case of a ball and socket joint such as the shoulder (and the hip) the restoration of function to the muscles of rotation requires a slightly different technique owing to the fact that the patient is unable to rotate the humerus in the glenoid cavity of the shoulder without first stabilizing the hinge joint at the elbow The patient subconsciously associates the region of the elbow with the rotation of the shoulder therefore, directing the brain path to this area at the elbow will be more effective in restoring function to the muscles performing the movements even though the muscles actually attach at the shoulder

The patient is placed supine upon the table and the forearm is kept somewhat flexed in order to stabilize the elbow joint

> *Mental Awareness* The attendant stands at the side of the table and directs the patient to concentrate upon the medial aspect of the elbow The hinge elbow joint is the stabilizing unit for the ball and socket shoulder joint The patient mentally follows the movement of internal rotation of the extremity while the attendant passively performs this movement (Figure 44) At the completion of internal rotation the patient is requested to mentally relax and to direct his mind to the lateral aspect of the elbow and to follow the movement of external rotation passively performed by the attendant (Figure 45) Three passive movements are carried out at one session

and fingers



Figure 44 The position and grip for commencing the movement of internal rotation of the upper extremity



Figure 45 The position and grip for commencing the movement of external rotation of the upper extremity

ble rather than the shoulders during the time that the three passive movements are performed by the attendant The attendant must see that the upper trapezius does not contract The inferior angle of the scapula must be anchored by the attachment of the latissimus dorsi

Muscle Function —When mental awareness and coordination have been restored the attendant requests the patient to do one active movement of the three allotted to this group at the end of the session All movements are assisted by the attendant until the patient is able to retain the position unaided

EXTENSION OF THE UPPER EXTREMITY

The patient is placed in the prone position on the treatment table The attendant stands beside the table on the affected side of the patient and proceeds to restore mental awareness coordination and muscle function to the teres major (Figure 47)

Mental Awareness —The attendant lifts the shoulder backward passively and directs the patient to anchor the tip of the scapula with the latissimus dorsi before transferring the mental effort to the teres major The mind of the patient is focused on the point of attachment of the teres major (crista tuberculi minoris) The attendant then brings the arm backward and upward through the full arc of motion while the patient mentally follows the movement Three passive movements are made The attendant supports the shoulder in the palm of her hand throughout the procedure

Coordination —The attendant watches carefully for any contraction that may occur in any



Figure 46 The position and grip for the restoration of function to the rhomboids Each shoulder is done individually and then simultaneously as shown here



Figure 47 The position and grip for extension of the upper extremity (The left hand of the instructor is indicating the point of attachment of the teres major while the right hand is indicating that the tip of the scapula must be anchored before performing the movement of extension of the limb)

results in a disorganization of the action of the ad ductors of the shoulder causing these muscles to attempt the assistance of the abductor in accordance with the artificial mechanical change maintained in the position of the joint and the unfolding of the capsular ligaments Deliberate incoordination is thus established When abduction is desired the adductors will contract and attempt to assist in abduction

When it is noticed that the deltoid is apparently paralyzed the condition of spasm may usually be found to be affecting the opposing pectoralis major or latis simus dorsi (Figure 28) This results in the aliena tion of the deltoid Placing the extremity in abduction causes further spasm and destruction of the adductors so that contractures follow but the deltoid does not return to power by the position of abduction Rather is alienation made more permanent by the increased spasm in the adductors Contracture and shortening of the pectoralis muscle causes the shoulder to cup and the scapula to be pulled forward The rhomboids having been pulled beyond their normal resting length are thus caused to become alienated and to have lost all power of contraction although they are not in them selves affected by the disease

other group and immediately commands general relaxation of all muscle groups The latissimus dorsi must be especially noted as this muscle may contract strongly and adduct the arm to the body, which action is incorrect

Muscle Function —When it is felt that the brain path and coordination have been restored the pa tient is requested to make the third movement actively after the first two passive movements The movements allotted to the patient are gradually increased until all three are performed actively The attendant supports the arm and assists all movements until full voluntary function has been re established

COMMENTARY

The shoulder joint with its ball and socket articula tion is capable of many motions The muscles of the shoulder region necessarily have a complex inter rela tionship with each other in order to accommodate for the normal motions of the joint *Deformities that occur* when treatment is not satisfactorily carried out are de *ploringly frequent and very disabling* Too much em phasis cannot be placed upon the importance of not allowing any muscle to become shortened When full relaxation is not possible in one group full contracti bility will be impossible in the opposing group

Especially to be mentioned and condemned is the procedure used in the past of maintaining the upper extremities in abduction This position allows the tra pezius and the deltoid to shorten and form permanent contractures *The shortening of the deltoid is respon* sible for the semi dislocation of the head of the humerus *frequently* noticed where this procedure has been used Maintaining the upper extremities in abduction also

RESTORATION OF FUNCTION

Muscles of the Forearm and Hand

Flexion and Extension of the Forearm—First Movement

These exercises are usually performed alternately with each other at a single session but if one group is stronger than the opponent the major attention is given to the weaker group and this group may be treated separately The procedure for each group will be described separately The patient is placed in the supine position on the treatment table The attendant slightly abducts the arm and places the elbow of the patient in the palm of her hand (R or L) and supports the forearm of the patient with either the right or the left hand, depending upon the side as shown in Figure 48 The attendant then proceeds to restore mental awareness coordination and function to the flexors and extensors of the forearm

Flexion—*First Movement* (to convey the wrist toward the shoulder)

Mental Awareness—Holding the forearm supinated the attendant requests the patient to visualize the point of attachment of the biceps brachii (tuberositas radii) The brachialis muscle whose insertion is on the tuberositas ulnae works in con

of attachment of the triceps (olecranon ulnæ) The attendant passively extends the forearm to full extension while the patient mentally follows the movement

Coordination —The biceps and triceps function synchronously in flexing and extending the elbow joint Great care must be exercised during re education *to work in the range of motion within* which both muscles exert the most effective con traction as has been described If the forearm is wrongly carried to the fully flexed position the triceps is overstretched and both the biceps and triceps will be relaxed A most confused and inco ordinate effort will then ensue in which the patient will be observed to attempt extension of the fore arm by using all of the muscles of the shoulder girdle

Muscle Function —When the attendant feels that mental awareness of the part has been re stored and incoordination combatted she requests the patient to put forth a physical effort to per form the movement This effort must in all cases be mentally controlled by the patient and phys ically guided by the attendant The active move ment is allowed at the end of the session i e when two passive movements have been perform ed by the attendant With returning power, the active movements allowed are worked up to in clude all three These are guided by the attendant and later resisted as power increases

FLEXION AND EXTENSION OF THE FOREARM—SECOND MOVEMENT

FLEXION—*Second Movement* (to convey the wrist toward the *mouth)*

Mental Awareness —The position of the patient and the grip of the attendant is maintained as in

junction with the biceps brachii in flexion of the forearm in the supinated position. The attendant passively flexes the forearm of the patient while the patient mentally follows the movement The motion is carried only to the right angle position of flexion of the elbow as beyond this point the biceps begins to relax and does not give a strong contraction Upon completion of the movement *the patient is instructed to relax and prepare to* transfer his attention to the attachment of the triceps muscle to begin the reverse movement of extension of the forearm The attendant flexes the forearm passively three times at each session

Coordination —The patient is watched closely to see that no effort is made in any other muscle group than the one being trained

Muscle Function —When the attendant feels that the brain path has been restored, the patient is requested to put forth a physical effort at the end of the session, i e, the *third movement The* effort must still be concentrated, both mentally any physically, on the group from which an action is expected in order to insure coordination The movements allotted to the patient are gradually increased, i e, one passive with two active and finally all three active movements All movements are guided by the attendant until full voluntary function has been restored The movements are *first assisted and later resisted* by the attendant

EXTENSION OF THE FOREARM

From the position obtained in flexion of the fore arm, the attendant proceeds to restore mental awareness, coordination and function to the triceps muscle

Mental Awareness —The patient is requested to transfer his mental concentration from the point of attachment of the biceps brachii to the point



Figure 48 The position and grip for flexion and extension of the forearm The illustration shows the position for the first movement in which the biceps flexes the wrist toward the shoulder The second position with the forearm in semi pronation (Figure 49) flexes the wrist toward the mouth and exercises the brachioradialis



Figure 49 The position and grip for the supinators and pronators of the forearm (biceps brachii and pronator teres) The elbow is at a right angle

Figure 48 The forearm of the patient is then semipronated The patient is directed to concentrate mentally on the insertion of the brachioradialis (above the processus styloideus radii) The *attendant passively flexes the forearm requesting* that the patient not make any physical effort The attendant flexes the forearm passively three times bringing the wrist toward the mouth

Coordination —The patient is watched closely to see that no physical effort is put forth in any *muscle group other than the one being trained*

Muscle Function —When the attendant feels that the brain path has been restored, the patient *is requested to put forth a physical effort at the* end of the session i e, the third movement The active movements are gradually increased as previously described

EXTENSION OF THE FOREARM

From the position obtained by flexion of the forearm the attendant proceeds to extend the forearm as explained in Extension Movement Number One The movements allotted to the patient are gradually increased until all three are performed actively All movements are guided by the attendant, at first with assistance and later with resistance

PRONATION AND SUPINATION OF THE FOREARM WITH THE ELBOW FLEXED 90°

These movements are performed alternately at one treatment session providing opposing groups are equally affected If they are not equally affected, the major attention is given to the weaker group *The procedures* will be described separately The patient is placed *upon the treatment* table in the supine position The

patient is requested to mentally transfer his attention to the point of attachment of the pronator teres (lateralis radii) The attendant then guides the movement passively in pronation

Coordination —The attendant takes special care that no other muscle group shall endeavor to perform the action or contract in any way

Muscle Function —The attendant requests the patient to perform one active movement at the end of the session when it is perceived that mental awareness and coordination have been restored The active movements are gradually increased, i e to one passive with two active and finally to the full three movements active The movements are all guided being at first assisted and later resisted by the attendant

PRONATION AND SUPINATION OF THE FOREARM WITH THE ELBOW IN EXTENSION

The patient and attendant remain in the position portrayed in Figure 49 The forearm is placed with the elbow in extension and the procedures just outlined are repeated The alteration in mechanics entails

Pronation —The patient is requested to visualize the point of attachment of the pronator quadratus (facies volaris radii) on the volar surface of the forearm near the wrist

Supination —The patient is requested to visualize the point of attachment of the supinator longus (brachioradialis) just above the processus styloideus radii

attendant stands at the side of the table and grasps the patient's hand as is done in shaking hands (Figure 49) The elbow is held flexed at 90° The attendant then proceeds to restore mental awareness, coordination and function to the muscles of pronation and supina tion of the forearm

SUPINATION

Mental Awareness—The patient is directed to concentrate mentally upon the point of attach ment of the biceps brachii (tuberositas radii) The attendant passively supinates the forearm while the patient follows the movement mentally From the position of supination, the patient is requested to relax and transfer his mental efforts to the point of attachment of the pronator teres in order to prepare to reverse the movement to pronation The movement is carried out three times passively at each session

Coordination—The attendant takes every pre caution to see that the movement is performed by *the right muscle group The patient is particularly* cautioned not to attempt to use the wrist or hand

Muscle Function—When it is found that the brain path has been restored, the patient is allowed to make one active movement, i e, at the end of the session after two passive movements All move ments
guided
to the
three are performed actively

PRONATION

Mental Awareness—From the position of su pination obtained in the previous movement, the

make one active movement at the end of the session i e, following two passive movements The active movements are gradually increased to include all three movements of one session The attendant guides and controls all movements until full voluntary control by the patient has been resumed

Flexion (metacarpo phalangeal joints)

While each individual finger (or thumb) is in the position of extension as seen in Figure 50 the attendant directs the patient to transfer his mental effort to the palmar surface of the base of the finger (or thumb) The attendant then brings each finger back to the table Muscles receiving attention for flexion at the metacarpo phalangeal joints are the flexor pollicis brevis and the lumbricals Active movements are allowed the patient when muscle function has been restored

Abduction and Adduction of the Thumb

The patient maintains the supine position with the hand prone upon the treatment table The attendant proceeds to restore mental awareness coordination and function to the abductors and adductors of the thumb

Mental Awareness—

Abduction —The attendant focuses the mind of the patient upon the point of attachment of the abductor pollicis longus and brevis (metacarpalis I and the base of the first phalanx of the thumb laterally) and then passively abducts the thumb

Adduction —With the thumb in the position obtained in abduction the patient is requested

THE MUSCLES OF THE FINGERS AND HAND
METACARPO PHALANGEAL JOINTS
FLEXION AND EXTENSION

EXTENSION

The patient is placed in the supine position on the treatment table with the pronated hand resting flat upon the table (Figure 50) The thumb and index finger of the attendant s right hand grasp the sides of the tip of the thumb and each finger of the patient in turn The attendant proceeds to restore mental awareness coordination and function first to the extensors and then to the flexors by alternate movements at the one session The muscles performing extension of the metacarpo phalangeal joints are the extensor pollicus brevis extensor digitorum communis extensor indicis proprius and extensor digiti quinti

Mental Awareness—To restore the brain path the patient is requested to concentrate upon the point of attachment of the extensor pollicis brevis and extensor digitorum communis to the dorsal surface of the first phalanges of the thumb and each finger The attendant guides the passive movements each of which are performed three times for each finger From the position obtained in extension the patient is requested to relax and transfer his attention to the volar surface to reverse the motion

Coordination—The attendant sees that incoordination is combatted in the effort of movement by taking particular precaution to prevent any contraction of the wrist extensors and flexors

Muscle Function—When the brain path has been restored the attendant allows the patient to

make one active movement at the end of the session, i.e., following two passive movements. The active movements are gradually increased to include all three movements of one session. The attendant guides and controls all movements until full voluntary control by the patient has been resumed.

FLEXION (metacarpo-phalangeal joints)

While each individual finger (or thumb) is in the position of extension as seen in Figure 50, the attendant directs the patient to transfer his mental effort to the palmar surface of the base of the finger (or thumb). The attendant then brings each finger back to the table. Muscles receiving attention for flexion at the metacarpo-phalangeal joints are the flexor pollicis brevis and the lumbricals. Active movements are allowed the patient when muscle function has been restored.

ABDUCTION AND ADDUCTION OF THE THUMB

The patient maintains the supine position with the hand prone upon the treatment table. The attendant proceeds to restore mental awareness, coordination and function to the abductors and adductors of the thumb.

Mental Awareness—

Abduction.—The attendant focuses the mind of the patient upon the point of attachment of the abductor pollicis longus and brevis (metacarpalis I and the base of the first phalanx of the thumb laterally) and then passively abducts the thumb.

Adduction.—With the thumb in the position obtained in abduction, the patient is requested

THE MUSCLES OF THE FINGERS AND HAND
METACARPO PHALANGEAL JOINTS
FLEXION AND EXTENSION

EXTENSION

The patient is placed in the supine position on the treatment table with the pronated hand resting flat upon the table (Figure 50) The thumb and index finger of the attendant's right hand grasp the sides of the tip of the thumb and each finger of the patient in turn The attendant proceeds to restore mental awareness coordination and function first to the extensors and then to the flexors by alternate movements at the one session The muscles performing extension of the metacarpo-phalangeal joints are the extensor pollicus brevis, extensor digitorum communis, extensor indicis proprius and extensor digiti quinti

Mental Awareness —To restore the brain path the patient is requested to concentrate upon the point of attachment of the extensor pollicis brevis and extensor digitorum communis to the dorsal surface of the first phalanges of the thumb and each finger The attendant guides the passive movements, each of which are performed three times for each finger From the position obtained in extension, the patient is requested to relax and transfer his attention to the volar surface to reverse the motion

Coordination —The attendant sees that incoordination is combatted in the effort of movement by taking particular precaution to prevent any contraction of the wrist extensors and flexors

Muscle Function —When the brain path has been restored, the attendant allows the patient to



Figure 50 The position and grip for the restoration of function to the muscles of flexion and extension of the metacarpo-phalangeal joints



Figure 51 The position and grip for the restoration of function to the opponens pollicis

to transfer his attention to the *point of inser tion* of the adductor pollicis (base of the first phalanx of the thumb) The attendant guides the passive action of moving the thumb toward the hand

This procedure (abduction and adduction) is done a total of three times The patient is re quested to attempt no physical effort but to fol low the movement mentally

Coordination — The attendant carefully ob serves that all the muscles other than those being trained are relaxed

Muscle Function —When it is found that the brain path has been re established the patient is allowed to make the third movement actively i e after two passive movements by the attendant The active movements are gradually increased al lowing two active after one passive and finally all three movements active These movements are guided by the attendant

ABDUCTION AND ADDUCTION OF THE FINGERS

The patient retains the supine position as depicted in Figure 50 with the hand pronated on the table The attendant proceeds to restore mental awareness co ordination and function to the palmar interossei dor sal interossei and the abductor digiti quinti

Mental Awareness—

Abduction

The patient is requested *to focus* his mind upon each finger at the side farthest away from the midline finger The attendant passively ab ducts the finger away from the midline of the midfinger

> *Coordination* —The attendant observes that no contraction occurs other than within the area desired It must be particularly noted that the flexor pollicis does not contract
>
> *Muscle Function* —When it is found that mental awareness and coordination have been restored the patient is allowed to make one active movement at the end of the two passive ones All movements are carefully guided by the attendant The movements allotted to the patient are gradually increased until all three at one session are performed actively

The opponens digiti quinti receives exercise during the above procedure for the opponens pollicis

FLEXION AND EXTENSION OF THE INTERPHALANGEAL AND METACARPO-PHALANGEAL JOINTS OF THE FINGERS

FLEXION

The patient is placed supine on the table as shown in Figure 52 with the elbow resting on the table The attendant proceeds to restore mental awareness coordination and muscle function

> *Mental Awareness* —The attendant grasps each finger in turn opposite the distal phalanx and proceeds to restore mental awareness to the flexor digitorum profundus flexor digitorum sublimis and the lumbricals The attendant focuses the mind of the patient upon the folding of the finger in rhythm
>
> *Coordination* —The attendant sees that no contraction occurs during this procedure in other muscles than the ones being trained

Adduction

After each finger is abducted from the mid line the patient is requested to transfer his thought to the opposite side of the finger The attendant then guides each finger in turn from the position of abduction to adduction carrying it back passively toward the midline of the mid finger Three passive movements are carried out for each finger No exercise is given the middle finger

Coordination —The attendant carefully ob serves that the movement is carried out by the abductors and adductors of each finger individ ually and does not allow any contraction in any other muscle group

Muscle Function —When it is felt that aware ness and coordination have been restored the pa tient is allowed to make one active assisted effort after the two passive movements The active effort is increased according to the restoration of power i e two active movements after one passive and finally all three active All movements are guided by the attendant until full voluntary function has been restored

OPPOSITION OF THE THUMB

The patient is placed in the supine position upon the treatment table as shown in Figure 51 The attendant grasps the thumb of the patient with the thumb and index finger and proceeds to restore mental awareness coordination and function to the opponens pollicis

Mental Awareness —The attendant focuses the mind of the patient upon the point of attachment of the opponens pollicis (ossis metacarpalis I) and passively moves the thumb volarward

> *Coordination*.—The attendant observes that no contraction occurs other than within the area desired. It must be particularly noted that the flexor pollicis does not contract.
>
> *Muscle Function*.—When it is found that mental awareness and coordination have been restored, the patient is allowed to make one active movement at the end of the two passive ones. All movements are carefully guided by the attendant. The movements allotted to the patient are gradually increased until all three at one session are performed actively.

The opponens digiti quinti receives exercise during the above procedure for the opponens pollicis.

FLEXION AND EXTENSION OF THE INTERPHALANGEAL AND METACARPO-PHALANGEAL JOINTS OF THE FINGERS

FLEXION

The patient is placed supine on the table as shown in Figure 52, with the elbow resting on the table. The attendant proceeds to restore mental awareness, coordination and muscle function.

> *Mental Awareness*.—The attendant grasps each finger, in turn, opposite the distal phalanx and proceeds to restore mental awareness to the flexor digitorum profundus, flexor digitorum sublimis and the lumbricals. The attendant focuses the mind of the patient upon the folding of the finger in rhythm.
>
> *Coordination*.—The attendant sees that no contraction occurs during this procedure in other muscles than the ones being trained.



Figure 52 The position and grip for restoring flexion and extension at the interphalangeal and metacarpo phalangeal joints of the fingers The elbow is held flexed if there is any spasm in the biceps brach

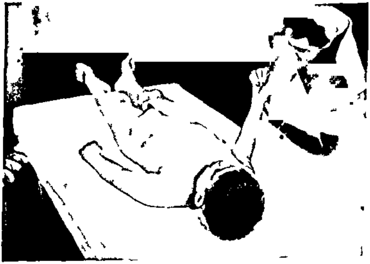


Figure 53 The position and grip for flexion and extension of the interphalangeal and metacarpo-phalangeal joints with all the fingers working in unison

Muscle Function —When it is found that the brain path has been restored the patient is allowed to do the movement actively after two passive movements The active movements are gradually increased to one passive with two active and finally all three movements are active All movements are guided by the attendant

Extension (interphalangeal and metacarpo-phalangeal joints)

From the position obtained in the flexion of these joints the attendant proceeds to restore mental awareness coordination and function to the extensor digitorum communis palmar interossei and dorsal interossei

Mental Awareness —The attendant directs the mind of the patient to the end of each finger while it is still flexed The finger is unfolded while the patient mentally follows the movement Each finger is thus treated in turn

Coordination —The attendant sees that no contraction occurs in any other muscle group than the one desired

Muscle Function —When mental awareness and coordination have been restored the patient is allowed to make one active movement after two passive ones All movements are guided by the attendant The movements allotted to the patient are gradually increased until all three at one session are performed actively

When function has returned to all the muscles of the groups performing flexion and extension of these joints the fingers may combine to perform the movements The patient flexes all his fingers in unison folding the *tips into the palm The patient then unfolds the hand* in rhythm The attendant guides these movements as depicted in Figure 53



Figure 52 The position and grip for restoring flexion and extension at the interphalangeal and metacarpo phalangeal joints of the fingers The elbow is held flexed if there is any spasm in the biceps brachii

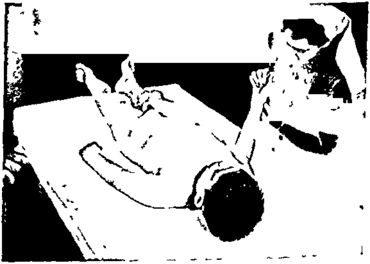


Figure 53 The position and grip for flexion and extension of the interphalangeal and metacarpo phalangeal joints with all the fingers working in unison

Muscle Function.—When it is found that the brain path has been restored, the patient is allowed to do the movement actively after two passive movements. The active movements are gradually increased to one passive with two active and finally all three movements are active. All movements are guided by the attendant.

EXTENSION (interphalangeal and metacarpo-phalangeal joints)

From the position obtained in the flexion of these joints the attendant proceeds to restore mental awareness, coordination and function to the extensor digitorum communis, palmar interossei and dorsal interossei.

Mental Awareness.—The attendant directs the mind of the patient to the end of each finger while it is still flexed. The finger is unfolded while the patient mentally follows the movement. Each finger is thus treated in turn.

Coordination.—The attendant sees that no contraction occurs in any other muscle group than the one desired.

Muscle Function.—When mental awareness and coordination have been restored, the patient is allowed to make one active movement after two passive ones. All movements are guided by the attendant. The movements allotted to the patient are gradually increased until all three at one session are performed actively.

When function has returned to all the muscles of the groups performing flexion and extension of these joints, the fingers may combine to perform the movements. The patient flexes all his fingers in unison, folding the tips into the palm. The patient then unfolds the hand in rhythm. The attendant guides these movements as depicted in Figure 53.

DORSIFLEXION AND VOLAR FLEXION OF THE WRIST

DORSIFLEXION

The patient is placed supine upon the treatment table and the attendant stands at the side of the table as shown in Figure 54 The attendant proceeds to restore mental awareness, coordination and function to the dorsiflexors of the wrist (extensor carpi radialis brevis, extensor carpi radialis longus and extensor carpi ulnaris)

Mental Awareness—The attendant supports the hand of the patient in her palm, holding the patient's thumb between her index and middle finger (to prevent the patient from using his abductor of the thumb) and directs the patient to concentrate upon the points of attachment of the dorsal muscles A single point between the bases of metacarpalis II and metacarpalis III is used to indicate the attachments of extensor carpi radialis longus and brevis while the base of metacarpalis V is used to indicate the point of attachment of extensor carpi ulnaris The attendant uses the tips of her index and middle fingers simultaneously to direct the mind of the patient to these points on his wrist (Figure 54) The wrist is then dorsiflexed passively by the attendant while the patient follows the movement mentally Three passive movements are made

Coordination—The attendant observes that only the dorsal muscles of the hand are in contraction or attempting to contract The muscles of the fingers or other muscles of the forearm are not allowed to assist It must be seen that the thumb abductor does not attempt the movement

Muscle Function—When it is observed that the brain path and coordination have been restored,



Figure 54 The position and grip for dorsiflexion of the wrist



Figure 55 The position and grip for palmar flexion of the wrist

the patient is allowed to perform one active motion at the end of the session, i e, after two passive movements All movements are guided by the attendant The movements allotted to the patient are gradually increased to one passive with two active and finally all three are active movements

VOLAR FLEXION

The patient retains the supine position as just described but the hand is turned over in supination as shown in Figure 55 The attendant proceeds to restore mental awareness, coordination and function to the volar flexors of the wrist, the flexor carpi radialis flexor carpi ulnaris and palmaris longus

Mental Awareness—The patient is directed to concentrate his attention to the points of attachment of the volar flexors (basis os metacarpalis II and III for flexor carpi radialis and os pisiforme for flexor carpi ulnaris) The attendant then guides the movement of wrist flexion while the patient follows the movement mentally

Coordination—The attendant observes carefully that contraction does not occur in any other muscle group than the one being trained, particularly the finger flexor muscles

Muscle Function—When it is found that the brain pathway has been restored, the patient is allowed to make one guided active movement at the end of the session i e after the two passive movements The active movements are gradually increased to one passive with two active and finally to all three active movements at one session All movements are carefully guided by the attendant until full voluntary control by the patient has been resumed

RADIAL AND ULNAR ABDUCTION OF THE WRIST

RADIAL ABDUCTION

The patient is placed supine upon the treatment table and the attendant stands at the side of the table as shown in Figure 56 The hand is placed prone in midline alignment with the forearm before proceeding with the exercises The attendant proceeds to restore mental awareness coordination and function to the radial abductors of the wrist the extensor carpi radialis longus extensor carpi radialis brevis and flexor carpi radialis

Mental Awareness—The attendant focuses the mind of the patient to the dorsal surface of the basis os metacarpalis II and passively brings the hand into abduction to the thumb side The patient is directed to follow the movement mentally Upon reaching abduction the patient is instructed to relax and the hand is returned to the midline neutral position The movement is done passively three times

Coordination—The attendant observes that no effort is made by any other muscle group to achieve this action

Muscle Function—When the attendant finds that the brain path and coordination have been restored the patient is allowed to make one active movement at the end of the session which should consist of two passive and one active movements All movements are guided by the attendant The movements allotted to the patient are gradually increased until all three at one session are performed actively

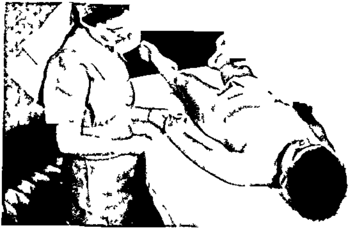


Figure 56 The position and grip for radial abduction of the wrist (In the illustration the movement has already been carried out)



Figure 57 The position and grip for ulnar abduction of the wrist (In the illustration the movement has already been carried out)

ULNAR ABDUCTION

The hand of the patient, which has assumed the neutral position from radial abduction, is in perfect alignment with the forearm The attendant proceeds to restore mental awareness, coordination and function to the flexor carpi ulnaris and extensor carpi ulnaris

Mental Awareness—The attendant focuses the mind of the patient to the dorsal aspect of the basis os metacarpalis V and supports the hand while it is guided passively into ulnar abduction toward the fifth finger side (Figure 57) The patient follows the movement mentally Upon completion of abduction, the patient is instructed to relax his attention and the hand is returned to the midline neutral position Three passive movements are given

Coordination—The attendant sees that contraction does not occur in any other muscles than those required to achieve this action

Muscle Function—When it has been ascertained that mental awareness and coordination have been restored the patient is allowed to actively contract the muscles to perform abduction and also to restore the hand back to the midline neutral position All movements are guided by the attendant The active movements are gradually increased from two passive with one active to one passive with two active and finally to all three active movements at one session

RESTORATION OF FUNCTION

Muscles of the Trunk

THE muscles of the trunk constitute an extremely important group for maintaining the orthograde posture of man and for stabilizing and balancing the body during locomotion Good restoration of coordinate function of the muscles of the trunk will enable the patient to walk satisfactorily in most cases even in the presence of considerable weakness of the extremities It is therefore of great importance that the muscles of this region be thoroughly understood in order that proper re education be carried out The principal muscles of the trunk are the sacrospinalis the quadratus lumborum and the abdominals These muscles all work rhythmically and the action of one bears an integrated relationship to the behavior of the others

Before proceeding with the attempt to restore function to the trunk muscles it is necessary to have clearly in mind the difference in functional activity of the muscle groups

The abdominal muscles belong to Classification I muscles that contract within their normal resting length It is therefore of great importance to see that all muscles of the group are retained within the normal resting length neither allowing them to shorten nor to

be stretched beyond this length The abdominal muscles as a group bend the spinal column forward The lateral components are able to bend the spine to the side and to rotate it individually

The sacrospinal muscles as a full group belong to Classification II, muscles that have to be removed from their normal resting length before a satisfactory contraction can occur The difference in the sacrospinalis group of muscles and all other groups is owing to the many different origins, insertions and actions controlled by the group and the number of joints or vertebræ included in their length Any shortening of this group such as may occur by neglect of treatment of the condi*tion of spasm will have serious consequences upon the* action of the posterior group itself as well as upon the other muscles of the trunk The sacrospinal muscles are a group which, when used in unison, bend the spinal column backward and are the opposing group to the abdominals Therefore, to achieve full extension of the spinal column, this group must be removed from their normal resting place by the *full* contraction of the abdominals

Included in the sacrospinalis group are the *iliocos*tales lumborum with insertion by nine processes, the *lower ones fleshy and the upper ones thin and tendin*ous, to the angles of the twelfth to the fourth ribs The *spinal action of the iliocostalis lumborum* is to depress the ribs, therefore, when working alone it *will contract within its own resting length* The iliocostales lumborum normally contract within their *normal resting length* Therefore, when the spine is flexed forward, this group has been removed beyond its normal resting length and is unable to contract sat

isfactorily until the spine has been returned to normal alignment by other components of the sacrospinalis group When this has been achieved the iliocostales lumborum will contract and assist to extend the whole spinal column backward to beyond normal alignment of the upright body This is allowed presumably owing to the fact that the iliocostalis lumborum can depress the twelfth to the fourth ribs and shorten the spinal length A depression of the ribs would mean a relative lengthening of the abdominals and thus allow the desired slack from the abdominals to be taken up by the iliocostales lumborum and satisfactory contraction achieved

Enforced shortening such as may occur through immobilization or shortening through neglect of the condition of muscle spasm of any muscle attached to the trunk or pelvis will have a far reaching and damaging effect upon the body Spasm of the obliquus abdominis externus and internus will cause the pelvis to be lifted on the side involved bringing the pelvis nearer the ribs and giving the patient the appearance of leg shortening on that side (Figure 7) If allowed to persist this will curve the spine to the opposite side and the deformity of scoliosis will result The ribs being pulled toward the pelvis on the affected side will cause the ribs of the opposite side to be barreled outward

Shortening of the iliopsoas and sartorius muscles as has been encouraged in the past by immobilizing the patient in the hip flexed position will result in fixed lordosis and will stretch the abdominals The abdominals being persistently pulled beyond their normal resting length and prevented from being restored to the normal resting length within which they can function

be stretched beyond this length The abdominal mus cles as a group bend the spinal column forward The lateral components are able to bend the spine to the side and to rotate it individually

The sacrospinal muscles as a full group belong to Classification II, muscles that have to be removed from their normal resting length before a satisfactory con traction can occur The difference in the sacrospinalis group of muscles and all other groups is owing to the many different origins, insertions and actions controlled by the group and the number of joints or vertebræ included in their length Any shortening of this group such as may occur by neglect of treatment of the condi tion of spasm will have serious consequences upon the action of the posterior group itself as well as upon the other muscles of the trunk The sacrospinal muscles are a group which, when used in unison, bend the spinal column backward and are the opposing group to the abdominals Therefore, to achieve full extension of the spinal column this group must be removed from their normal resting place by the full contraction of the abdominals

Included in the sacrospinalis group are the iliocos tales lumborum with insertion by nine processes, the lower ones fleshy and the upper ones thin and tendin ous, to the angles of the twelfth to the fourth ribs *The spinal action of the iliocostalis* lumborum is to depress the ribs, therefore, when working alone it will contract within its own resting length The iliocostales lumborum normally contract within their normal resting length Therefore, when the spine is flexed forward, this group has been removed beyond its normal resting length and is unable to contract sat

isfactorily until the spine has been returned to normal alignment by other components of the sacrospinalis group When this has been achieved the iliocostales lumborum will contract and assist to extend the whole spinal column backward to beyond normal alignment of the upright body This is allowed, presumably, owing to the fact that the iliocostalis lumborum can depress the twelfth to the fourth ribs and shorten the spinal length A depression of the ribs would mean a relative lengthening of the abdominals and thus allow the desired slack from the abdominals to be taken up by the iliocostales lumborum and satisfactory contraction achieved

Enforced shortening, such as may occur through immobilization or shortening through neglect of the condition of muscle spasm, of any muscle attached to the trunk or pelvis will have a far reaching and damaging effect upon the body Spasm of the obliquus abdominis externus and internus will cause the pelvis to be lifted on the side involved, bringing the pelvis nearer the ribs and giving the patient the appearance of leg shortening on that side (Figure 7) If allowed to persist, this will curve the spine to the opposite side and the deformity of scoliosis will result The ribs being pulled toward the pelvis on the affected side will cause the ribs of the opposite side to be barreled outward

Shortening of the iliopsoas and sartorius muscles as has been encouraged in the past by immobilizing the patient in the hip flexed position will result in fixed lordosis and will stretch the abdominals The abdominals being persistently pulled beyond their normal resting length and prevented from being restored to the normal resting length, within which they can function

will be unable to give a satisfactory contraction Al though not directly affected by the disease these mus cles will appear paralyzed, become toneless and use less and will allow the abdomen to bulge outward It will be impossible to restore the abdominal muscles to function unless they can be returned to their normal resting length

Trunk deformities may also be brought about by spasm in the posterior spinal muscles if they are left un attended Shortening, caused by spasm in the sacro spinalis muscles, will cause a lordosis of the spine This will stretch the opposing abdominal muscles beyond their normal resting length and will cause them to ap pear paralyzed when in reality the abdominals in this case suffer from alienation If the spine is arched and kept in this position by shortened and contracted spinal muscles it will be impossible for the abdominal muscles to contract and raise the trunk as the spinal muscles cannot be released from their shortened position to allow the abdominal muscles to return to their normal resting length to perform a satisfactory contraction Apparent paralysis of the abdominal muscles is fre quently due to unreleased spasm of the opposing spinal muscles The spinal column is watched most carefully for any deviation from normal alignment Spasm of the spinal muscles on one side will cause the spine to bow sideways and eventually produce the deformity of scoliosis if the condition is not promptly attended in the acute stage of the disease

Spasm in the quadratus lumborum muscle will have a most damaging effect upon the body mechanics if left unattended This muscle in spasm causes the pelvis on the side affected to be drawn up toward the ribs

and the trunk to be arched forward on the side affected (Figure 4) This will result in permanent deformities unless the muscle condition is promptly treated Spasm of the quadratus lumborum will especially cause a pelvic tilt and an apparent leg shortening on the side affected

Before proceeding to restore function to the trunk muscles, the attendant must have made sure that all muscles have been returned to their proper resting length, none being either abnormally lengthened or shortened She must also understand the function and reciprocal action of the muscle groups in their inter-relationship to each other Lastly she must be sure that each group is re educated to its proper stabilizing function for the upright posture

The sacrospinalis group as a whole belongs to Classification II, muscles that have to be removed from their normal resting length before a satisfactory contraction can occur When the head and trunk are flexed forward with the spine arched, the full group has been stretched beyond its normal resting place The components of the full group contract rhythmically to return the trunk to normal alignment The iliocostalis lumborum, when acting alone, is a group that contracts within its normal resting length Immediately that this group has been returned to its normal resting length, a rhythmic contraction occurs beginning at the attachment to the fourth rib and proceeding downward in sequence to the twelfth rib so that a full extension of the spine follows by the action of this group The iliocostalis lumborum is a powerful extensor of the spine as well as a stabilizer In the restoration of func

tion to the sacrospinalis group, the major attention is devoted to the iliocostalis lumborum although the full group is brought into action by the treatment

THE ILIOCOSTALES LUMBORUM

To restore function to these muscles, the patient is placed prone upon the treatment table The attendant stands at the side of the table and proceeds to restore mental awareness, coordination and function to the sacrospinalis group

Mental Awareness —The patient is requested to focus his mind upon the insertions of the iliocos talis lumborum at the fourth to the twelfth ribs The attendant, standing at the side of the patient places one arm under the chest of the patient if a child while the other hand supports the knees as in Figure 58 The attendant then passively ex tends the spine while the patient mentally follows the movement If the patient is an adult, an as sistant is required to lift the shoulders backward while the attendant raises the lower limbs simul taneously to perform the movement of extension of the spine *Three passive movements are car ried out at one session*

Coordination —When the iliocostales lumborum function and extend the spine, the muscles are noted as well marked and contracted structures on either side of the spine The patient is watched most carefully to see that an equal con traction occurs on both sides If it is found that one side is lagging the attendant endeavors to concentrate upon the weaker side and bring it up to equal strength with the stronger side This is done by requesting the patient to focus the mind upon the weak side only, while the attendant con trols the mental effort of the patient by placing



Figure 58 The position and grip for the restoration of function to the sacrospinalis group



Figure 59 The position and grip for the restoration of function to the quadratus lumborum Note the limb is not raised from the table as this would bring the iliocostalis lumborum into action

tion to the sacrospinalis group, the major attention is devoted to the iliocostalis lumborum, although the full group is brought into action by the treatment

THE ILIOCOSTALES LUMBORUM

To restore function to these muscles, the patient is placed prone upon the treatment table The attendant stands at the side of the table and proceeds to restore mental awareness, coordination and function to the sacrospinalis group

> *Mental Awareness* —The patient is requested to focus his mind upon the insertions of the iliocostalis lumborum at the fourth to the twelfth ribs The attendant, standing at the side of the patient places one arm under the chest of the patient, if a child, while the other hand supports the knees as in Figure 58 The attendant then passively extends the spine while the patient mentally follows the movement If the patient is an adult, an assistant is required to lift the shoulders backward while the attendant raises the lower limbs simultaneously to perform the movement of extension of the spine Three passive movements are carried out at one session
>
> *Coordination* —When the iliocostales lumborum function and extend the spine, the muscles are noted as well marked and contracted structures on either side of the spine The patient is watched most carefully to see that an equal contraction occurs on both sides If it is found that one side is lagging, the attendant endeavors to concentrate upon the weaker side and bring it up to equal strength with the stronger side This is done by requesting the patient to focus the mind upon the weak side only, while the attendant controls the mental effort of the patient by placing

and its classification and type are carefully studied, it will be understood how impossible it would be for the gluteus medius to cause this limp Specifically, the glu teus medius has one fibrous origin and one tendinous insertion, therefore, one action (to abduct the thigh) It has no connection with the trunk and therefore could not in any way stabilize the trunk on the pelvis Any contraction of the gluteus medius would mean that its one action has been achieved, i e, the thigh abducted On the other hand if the quadratus lum borum is not supporting the pelvis to the twelfth rib, the pelvis will automatically drop on the side affected and the patient will limp

Great care must be exercised to restore the quadratus lumborum group This muscle has a fleshy or fibrous attachment to the inner lip of the crest of the ilium and to the twelfth rib and tendinous to the transverse processes of the lumbar vertebræ It is a mechanical law for every muscle to pull from its point of attachment The quadratus, in pulling from tendinous insertions on the vertebræ and with contrac tion of the fibrous attachments to the pelvis and twelfth rib, achieves a good stabilization of these parts The importance of securing action in this muscle cannot be overemphasized To restore function to the quadratus lumborum, the patient is placed upon the treatment table in the prone position as shown in Figure 59 The attendant proceeds to restore mental awareness, co ordination and muscle function to the muscle

Mental Awareness —The action of the quadra tus lumborum is to draw the pelvis and ribs together on the given side, lifting the pelvis upward to the twelfth rib and bending the spine lateral-

the points of her fingers lightly upon the side where a contraction is expected to occur The patient is kept in the prone position and the lower limb corresponding with the side that is receiving treatment is raised by the attendant while the patient is requested to simultaneously raise the head and shoulders from the table During these exercises the patient is instructed to allow his arms to hang loosely (Figure 58)

Muscle Function—When it is found that the brain path and coordination of the two sides have been restored, the patient is allowed to make one guided, assisted movement actively, i e, after two passive movements Guidance and assistance are continued at each session but the active movements are gradually increased to one passive with two active and finally to three active Voluntary un assisted efforts are allowed after full function has been restored to the spinal muscles

THE QUADRATUS LUMBORUM

The main function of the quadratus lumborum mus cle is to stabilize the trunk upon the pelvis in the lateral plane This is extremely important in walking In ability of the patient to stabilize the pelvis and trunk will result in serious impairment of balance with resulting poor gait It will be noticed that if this mus cle is weak on either the right side or the left side, the trunk will drop from the affected side when walking and the spine will lose its alignment The limp which results from loss of stabilizing function of the quadratus lumborum has frequently been mistakenly ascribed to the gluteus medius

The idea that the gluteus medius is a stabilizer is incorrect If the origin and insertion of the muscle

length A condition of lordosis, from whatever source, stretches the abdominals beyond their normal resting length In this case, it will be impossible to secure a normal contraction from the abdominal muscles until the spine is restored to normal alignment and the abdominal muscles replaced to their normal length

To restore function to the abdominal muscles, the patient is placed supine upon the treatment table The attendant stands at the side and proceeds to restore mental awareness, coordination and function to the abdominal muscles Three groups are under consideration, the right lateral abdominals, the left lateral abdominals and the central rectus abdominis

> *Mental Awareness* —The attendant attempts to restore mental awareness to each group individually by requesting the patient to focus his mind upon the particular area where the brain path is desired to be restored, i e , to the right or left lateral abdominals or to the central rectus abdominis The attendant proceeds to endeavor to assist the restoration of the brain path by directing the contraction, as far as possible, by means of lifting the leg on the side from which a contraction is desired, simultaneously with flexing the head (Figure 60) The patient follows the movement mentally Three passive movements are given each group at a session
>
> *Coordination* —The attendant will take particular care to see that all other muscles of the body are completely relaxed
>
> [illegible]

restored The attendant then endeavors to obtain

ward toward the opposite side The attendant supports the lower limb corresponding to the side being exercised upon her hand and forearm but *does not appreciably lift the limb from the table* The patient is requested to mentally focus upon the attachment of the muscle to the lumbar vertebræ laterally and he is instructed that the action to be accomplished is to draw the pelvis and ribs together on the side The attendant lifts the side of the pelvis upward toward the twelfth rib by gently forcing the lower limb The patient is directed to mentally follow the movement but to make no physical effort Three passive movements are given at a session

Coordination—The attendant carefully observes that no other muscle group contracts for the action of the quadratus The latissimus dorsi must be especially watched and the patient not allowed to attempt to pull the shoulder down toward the pelvis

Muscle Function—When it is ascertained that the brain path and coordination have been restored the patient is allowed to make the movement actively after two passive movements Active movements are gradually increased to three at the session i e two passive with one active to one passive with two active and finally all three active The limb of the patient is supported and all movements must be assisted and guided by the attendant until full voluntary function has been established The action sought is that the side of the pelvis being exercised shall be lifted toward the twelfth rib

THE ABDOMINALS

The abdominal muscles belong to *Classification I* muscles that contract within their normal resting



Figure 60 The first position for restoring function to the abdominal muscles (one side)



Figure 61 The second position for restoring function to the abdominal muscles (all groups)

a rhythmic action in all three groups by directing the patient to make one active effort at the end of the session while the attendant raises both legs and simultaneously requests the patient to allow the head and trunk to flex slowly forward (Figure 61) Where there is unequal contraction on one side, the attention is concentrated upon the weaker side until both groups are contracting equally Assistance and guidance by the attendant are continued until the patient can flex the trunk from the supine position and come to sitting position unassisted Active movements are gradually increased to accomplish this by giving one passive with two active movements and finally all three active movements at a session The abdominal muscles are accessory muscles of respiration contracting to aid exhalation This action may be used to assist restoration of function to the abdominal muscles The patient after filling the upper chest is directed to exhale pulling the lower ribs in and down toward the pelvis while at the same time contracting the central rectus abdominis This procedure is described in the Chapter on the Respiratory System (Chapter V) The object is to secure rhythmic action of the abdominals working with the other of the anterior trunk muscles

RESTORATION OF FUNCTION

Muscles of the Lower Limbs

Flexors of the Thigh the Iliopsoas and Rectus Femoris

The patient is placed supine upon the treatment table. The attendant stands at the foot of the table if the patient is a child (Figure 62) but if the patient is an adult the attendant may stand by the side of the table (Figure 63). The attendant will support the thigh as shown and proceed to restore mental awareness, coordination and function to the muscle groups which perform flexion of the thigh.

> *Mental Awareness*.—The attendant will direct the mind of the patient to the point of attachment of the iliopsoas muscle (trochanter minor femoris) and will passively guide the movement of flexion of the thigh requesting the patient to mentally visualize the action to the exclusion of all other efforts either mental or physical. It will be noted in Figures 62 and 63 that no part of the hand or fingers of the attendant come in contact with the tendinous insertion of the sartorius muscle at the tuberositas tibiæ. This muscle frequently incoordinately attempts to perform hip flexion. Con

be successfully restored to the iliopsoas The arc of motion is small at first so as not to excite the hamstrings which are frequently in spasm Three passive movements are carried out at one session Where the iliopsoas is completely alienated or where the effort of contraction is minimal the muscle may be stimulated to greater function by the following procedure It is to be recalled that the iliopsoas is a muscle with tendinous origin and with tendinous insertion therefore capable of contracting from either end Pulling from the tendinous origin on the lumbar spine the psoas flexes the pelvis forward on the hips This ability to pull from the origin is made use of to direct greater impulse to the muscle The patient is placed as in Figure 64 The attendant supports the extremity with the thigh at a right angle and directs the mind of the patient to the insertion of the psoas at the trochanter minor femoris and attempts to restore awareness by carrying the hip through a small range of flexion The patient simultaneously flexes the head forward thus subconsciously directing impulse to the muscle fibers at the origin while the attendant focuses the brain path of the patient to the insertion

Coordination —The attendant must carefully observe that no other muscle groups are contracting particularly the sartorius and the adductors If the sartorius attempts to function this muscle must be thrown out of action by means of the grip shown in Figure 62 The attendant abducts the lower leg slightly making outward pressure at the ankle and inward pressure at the knee

When it is felt that the patient has definitely established mental awareness of the point of attachment of the iliopsoas group, the attendant will explain the coordinating action of this group with the obliquus abdominis on the corresponding side

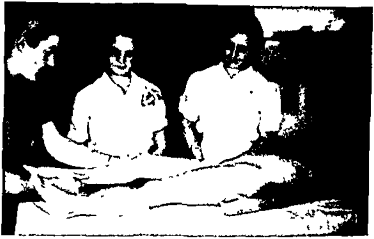


Figure 62 The position and grip for restoring function to the flexors of the thigh in the child patient.



Figure 63 The position and grip for restoring function to the flexors of the thigh in the adult patient (Male technicians are trained to *attend adult male patients*)

When the iliopsoas muscle flexes the thigh, the contraction of this muscle will cause the subconscious mind to direct the stabilization of the pelvis and trunk When the trunk is fixed, it is the work of the obliquus abdominis to stabilize the pelvis To obtain a forward movement, such as a step forward, the psoas lifts the thigh and the obliquus abdominis fixes the pelvis in rhythm For this reason these muscles must be taught to contract simultaneously in order to establish complete co ordination The iliopsoas begins the motion of hip flexion by rotating the head of the femur in the acetabulum, the rectus femoris then takes up the movement, lifting and supporting the thigh, the obliquus abdominis must support the pelvis simultaneously

Muscle Function —When mental awareness and coordination have been restored, the patient is allowed to make one active guided movement at the end of the session, i e , after two guided pas sive motions These are worked up to three active movements first with the assistance of the attend ant and later with resistance The arc of move ment must be left to the judgment of the attendant If it is found that the physical effort fades out when nearing completion of the full arc of movement, the attendant should determine this range and work within the arc of physical effort of the patient The angle of arc will be noted to increase with time

In some instances where there is poor power, the physical effort is appreciated by the attendant only at about the angle approaching right angle In this case the attendant guides the movement and supports the weight and notices the angle at which physical effort begins to be appreciated The attendant will slightly lessen the support from this angle and notice from time to time the in-



Figure 64 The position and grip for restoring function to the flexors of the thigh when the physical effort exerted by the muscle is weak The patient in flexing the head simultaneously with flexing the thigh secures maximum effort from the muscle in contracting from both its origin and insertion

length When the biceps femoris contracts to extend the thigh from the flexed position this allows the gluteus maximus to return to its normal resting position and enables it to fully contract and perform its stabilizing action

To prove that the gluteus maximus contracts only within its normal resting length, it is necessary to place a patient prone upon the treatment table with the lower extremities fully extended and request contraction of the gluteus maximus Full contraction can be obtained Then flex the thigh and request the gluteus maximus to contract This cannot be obtained It is necessary first for the long head of the biceps to bring the thigh into normal alignment and restore the gluteus maximus to its normal resting length before a full contraction can occur in this muscle with power to stabilize the lower limb and pelvis Great care must be exercised to intelligently return the gluteus maximus to its normal resting length and allow an even and rhythmic contraction to occur

The gluteus maximus has, in the past been generally although mistakenly, accepted as the extensor of the thigh The oblique position of this muscle in relation to the limb would according to mechanical law, make this function extremely unlikely It is possible that the patient might, by incoordinate action, if allowed use the gluteus maximus to attempt extension In this case it will be noticed that the patient externally rotates the limb and uses not only the gluteus maximus but the gluteus medius and minimus as well If allowed to persist in this activity the patient will learn to walk with the limbs in external rotation and the rhythm of his gait will be very much disturbed

crease of the arc within which physical effort is exerted

EXTENSION OF THE THIGH

Extension of the thigh is a function of the *biceps femoris muscle* The action is composed of two movements

1 *Restoration of the limb from the flexed position* to that of normal body alignment This is accomplished by the biceps femoris
2 Full extension sometimes called hyper extension This movement is also accomplished by the biceps femoris in conjunction with the other *hamstring muscles* To maintain the second position it is necessary for the gluteus maximus and the iliocostalis lumborum muscles to contract in unison and stabilize the pelvis and trunk after full extension of the limb has been *achieved by the biceps femoris*

The *biceps femoris is supplied with two heads* (a) *the long head from the* ischial tuberosity and (b) the short head from the linea aspera Contraction of the short head binds the long muscle to the linea aspera *allowing the long head to perform the movement of* extension of the thigh by pulling from this first insertion upon the femur The fibers of the long muscle at the ischial tuberosity are placed immediately *below* the gluteus maximus With the thigh in the flexed position the gluteus maximus is removed beyond its normal resting length and therefore no useful action can be obtained *from the gluteus maximus in the* lengthened position because it is of *Classification* I muscles that contract within their normal resting

Coordination —The attendant must observe that no contraction occurs in any other muscle

Muscle Function —When the brain path and coordination have been restored the patient is allowed to make the third movement actively i e after two passive movements Active contraction of the biceps femoris is usually not encouraged in this position until function also has been restored to the opposing hip flexors The movements allotted the patient are gradually increased until all three are performed actively with guidance at one session

SECOND MOVEMENT BICEPS FEMORIS GLUTEUS MAXIMUS ILIOCOSTALIS LUMBORUM

The patient is placed in the prone position upon the treatment table The attendant proceeds to restore mental awareness coordination and function to the muscles which carry the limb into full extension (hyper extension) and stabilize the body in the upright position both in standing and walking In order that the body may be stabilized in the upright position certain muscle groups must work in rhythm to stabilize the lower limbs pelvis and trunk The gluteus maximus stabilizes the thigh in alignment in the extended position It will be understood that the abdominal muscles as already described must contract to stabilize the position of flexion of the thigh in taking a step forward Consequently the opponents the iliocostales lumborum must have paid out slack and released the depression of the ribs to allow this to occur It naturally follows that when restoration of alignment has occurred stabilization must also be established Therefore in unison with the extension stabilization is necessary To achieve this the attendant will

The biceps femoris is an *important standing muscle* It will be noticed that, when a person is standing at ease, the gluteus maximus is not fully contracted there fore the biceps is giving support When an effort is made to step forward and the trunk has to be sup ported in the forward movement by one lower limb in the position of full extension of that limb it will be noticed that the gluteus maximus then comes into full contraction within its normal resting length

From the discussion presented, it will be understood how important it is in restoration of muscle function to see that equality of contraction is obtained in the hamstring muscles and more especially the outer ham *string*

EXTENSION OF THE THIGH

FIRST MOVEMENT *BICEPS FEMORIS*

The movement of extension of the thigh is usually carried out alternately with that of flexion but the pro *cedures are described separately From the* position obtained by contraction of the hip flexor muscles (Fig ure 62), the attendant will proceed to restore mental awareness coordination and function to the biceps femoris for the first movement from the flexed position i e restoring the thigh to normal alignment upright

> *Mental Awareness*—The attendant will direct the mind of the patient to the first insertion of the long head of the biceps femoris at the linea aspera and will slowly replace the *limb to the alignment of the body* The patient is requested not to put forth any physical effort but is informed that the biceps femoris is contracting and restoring the limb to correct alignment

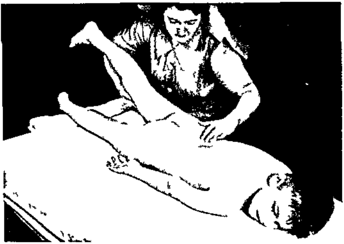


Figure 65c The position and grip for stabilizing the pelvis upon the trunk with the thigh in full extension the iliocostalis lumborum



Figure 65a The position and grip for extension of the thigh the biceps femoris



Figure 65b The position and grip for stabilization of the thigh in the fully extended position the gluteus maximus



Figure 66 The position and grip for restoration of function to the gluteus maximus of both sides

endeavor to restore mental awareness to the muscles that stabilize the body upright, i e, the iliocostales lumborum and the gluteus maximus working in unison If the iliocostales lumborum are not attended, rhythm cannot be restored The ribs are not held firmly *The proprioceptive reflexes are not receiving the* attention that is necessary to establish the acceptance of the sense of security to maintain the body upright

Mental Awareness—The attendant supports the limb at the knee and directs the mind of the patient to the attachment of the biceps femoris at the ischial tuberosity as shown in Figure 65a The limb is brought evenly into full extension while the patient mentally follows the movement As full extension is reached, the patient is directed to bring in the gluteus maximus to stabilize the extended position (Figure 65b) and finally to stabilize the pelvis upon the trunk by contraction of the iliocostalis lumborum (Figure 65c) The full movement is carried out passively three times at one session

Coordination—The attendant observes that the *three groups perform rhythmically in* sequence The attendant also observes that no other groups contract The gluteus medius is especially apt to attempt to assist by externally rotating the thigh *slightly This is noticed by a hollow or depression* just posterior to the trochanter major which appears when the gluteus medius contracts

Muscle Function—When it is observed that the brain path and coordination have been restored to *all groups, the patient is allowed to make one* active effort at the end of the session of three, i e, after two passive movements The limb must be supported and the entire *movement and* stabiliza-

each side just distal to the great trochanter and then places the palms of her hands one upon each buttock, as shown in Figure 66 The muscles are then passively brought toward the origin on the sacrum and posterior ilium by movement of the attendant's hands while the patient mentally fol lows the movement When it is determined that mental awareness has been restored the patient is requested to squeeze the buttocks together himself by voluntary contraction of the gluteus maximus muscles This procedure is frequently carried out just preceding that described for restoration of extension of the thigh

THE QUADRICEPS

The quadriceps are a group of muscles belonging to Classification II, muscles that must be removed from their normal resting length before a satisfactory con traction can occur If the standing and walking posi tion of man is considered it will be noted that the psoas muscle supports the thigh in flexion allowing the knee to bend so that the quadriceps can lengthen The op ponents (hamstrings) will take up the slack released by the lengthening of the quadriceps and will contract to maintain flexion of the knee and support the leg The quadriceps having been lengthened by the flexion of the knee, will then be ready to contract, extending the knee so that a step forward can be taken If the ham strings are tightened by unreleased spasm they will cause a brake to be put upon the quadriceps and this muscle will be unable to extend the knee because of the limitation imposed by the shortened hamstrings

To restore function to the quadriceps group, the pa tient is placed supine upon the treatment table The

tion be guided and directed by the attendant If one side is weaker than the other, the major attention *is given to the weaker side* The active movements are gradually increased with returning function, i e , to one passive with two active and finally *to three active* at one session This exercise requires guidance and control by the attendant until full voluntary function is established

THE GLUTEUS MAXIMUS

The gluteus maximus is an important muscle in stabilization of the body upright Therefore, great care must be taken to restore function to this muscle The *gluteus maximus is a muscle of Classification I*, being able to contract only within its normal resting length The hamstrings arising from the ischial tuberosity immediately below the gluteus maximus are very apt to stretch this muscle and cause alienation as the hamstrings are frequently in spasm and become elevated This will be noted by flattening or disappearance of the normal gluteal fold of the buttock

The gluteus maximus itself may be in spasm during the acute stage This is noted by the fact that the natal cleft will be widened and in extreme cases the anus exposed It is of great importance to recognize and treat these conditions of spasm in order to preserve *function of the gluteus maximus* muscle Besides the procedure described in the section on extension of the hip restoration of function of the gluteus maximus may be assisted in the following manner

The patient is placed in the prone position on *the treatment table* The attendant directs the mind of the patient to the attachment of each muscle to the gluteal tuberosity of the femur of



Figure 67a The position and grip for removing the quadriceps from their normal resting length before beginning restoration of function



Figure 67b The position and grip after extending the leg for contraction of the quadriceps

attendant supports the limb as shown in Figure 67a with the quadriceps lengthened by flexing the hip and the knee as in walking The attendant *then proceeds to restore mental awareness, coordination and function to the quadriceps*

Mental Awareness—The patient *is directed to* relax all muscles and focus the mind on the point of attachment of the *quadriceps (tuberosity of the tibia)* in their lengthened position The patient *is then requested to mentally follow the move* ment of extension of the leg and is informed that the attendant *is controlling the movement of one* step forward which is obtained by this action (Figure 67b) *The movement is carried out pas* sively three times at the session

Coordination—The attendant sees that the hamstrings are fully relaxed when the *leg is fully* extended and that no other muscle is contracting The attendant must also make sure that the full quadriceps group is contracting in rhythm If there is shortening of the iliotibial band or of the outer hamstring it will be noticed that this con dition alienates that portion of the quadriceps group pulling from the medial side The shorten ing must be rectified as soon as possible In exer cising the quadriceps in this case, *the hands of the* attendant are so placed that the thigh is abducted slightly while the pressure of one *hand adducts the* leg slightly This will favor the medial portion of the quadriceps so that equal *contraction of all* components will be secured

Muscle Function—When it is determined that *mental awareness* and coordination have been es tablished the patient is allowed to make one ac *tive movement* at the end of the session of three movements As power returns the patient is al

supported on both the medial and lateral sides, the weakly supported side will drop and cause foot deformities

FLEXION OF THE KNEE

To restore function to the hamstrings, the patient is placed supine upon the treatment table The thigh is flexed to the extent of taking one step forward

Mental Awareness —The mind of the patient is focused upon the points of attachment of the hamstring muscles posteriorly at the knee (semitendinosus and semimembranosus medially biceps femoris laterally) The patient is requested to flex the knee while the attendant observes by palpation of the tendons whether or not the muscles are contracting (Figure 68) If it is found that a weakness exists in either the inner or outer head the patient is placed in the prone position (Figure 69) and the mind of the patient is focused upon the point of attachment of the lagging side or upon both if function is lacking The movement of knee flexion is carried out passively three times by the attendant while the patient follows the movement mentally

Coordination —The attendant takes particular care to see as far as possible that contraction does not occur in the strong side until the weaker side is brought up to almost equal power It is entirely possible for the patient to contract either the medial or lateral hamstrings to the voluntary exclusion of the other The attendant must also observe that contraction within the muscle is coordinate i e beginning from the attachment at the knee and progressing smoothly toward the origin at the pelvis An incoordinate action is noted by a bunching up of the muscle at its upper end

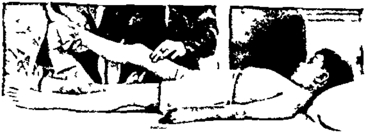


Figure 68 Knee flexion The position for determining incoordination of action of the hamstrings and for inequality of contraction of medial and lateral groups

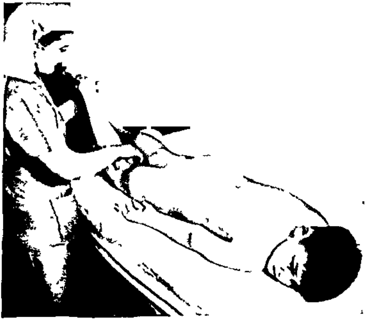


Figure 69 The position and grip for restoring function to the flexors of *the knee* *The attendant* focuses the mind of the patient upon the tendon of insertion of the weaker group or upon both if function is lacking

when the patient attempts knee flexion Such action, if allowed to persist would result in very ineffective action as the energy of the muscle is expended in pulling from the origin at the pelvis rather than from the insertion at the knee All muscles other than the hamstrings must be relaxed and no effort made at contraction

Muscle Function —The attendant passively performs three movements at each session in the position seen in Figure 69, until contraction is obtained in the non functioning or weaker group and until there is fairly equal contraction of both groups From then on there is performed two passive movements followed by one active, in the position seen in Figure 68 This is gradually worked upward to three active movements with the guidance and finally against the resistance of the attendant The active movements of flexion and extension of the knee may be performed alternately if power is good in both of the opposing muscle groups

ABDUCTION AND ADDUCTION OF THE THIGH

The principal abductor of the thigh is the gluteus medius a muscle belonging to Classification I, muscles that contract within their normal resting length The orthodox procedure of immobilizing the thighs in abduction was most damaging to this muscle because it encouraged shortening of the abductor The muscle by being shortened lost part of its potential power, but, more than that, the shortening imposed a serious restriction upon the contractibility of the opposing group, the adductors

The adductors of the thigh belong to Classification II, muscles that must be removed from their normal

resting length before a satisfactory contraction can occur To immobilize the limb in a position of abduction, as was commonly done in orthodox procedure, removes the adductors from normal resting length and has a very serious disorganizing effect upon this group as the adductors normally attempt contraction when removed beyond their normal resting length The only action that the adductor can perform when contracting within its normal resting length is to assist in flexing the thigh (adductor longus) When the individual muscle or group is alienated for its principal action the group will concentrate upon its second function and will endeavor to undertake incoordinately, full function of the secondary movement Where such condition has been allowed or encouraged to be maintained, it will be noticed that the adductor longus endeavors to undertake the work of full flexion of the thigh This causes the psoas to become mentally alienated and to eventually atrophy and become paralyzed from disuse

The movements of abduction and adduction are usually carried out alternately at one session but the procedures will be described separately

ABDUCTION OF THE THIGH

The patient is placed upon the treatment table in the supine position as shown in Figure 70 The attendant will proceed to restore mental awareness, coordination and function to the gluteus medius muscle

Mental Awareness—The attendant focuses the mind of the patient to the point of attachment of the gluteus medius (the *lateral surface of the* trochanter major near its apex) and passively



Figure 70 The position and grip for restoration of function to the abductors of the thigh

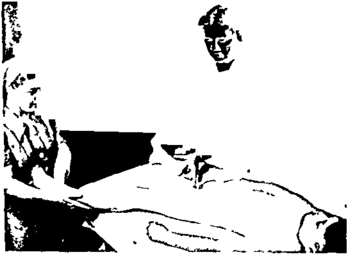


Figure 71 The position and grip for restoration of function to the adductors of the thigh

abducts the thigh while the patient mentally follows the movement Upon the thigh reaching the position of abduction, the patient is instructed to relax and to transfer the attention to the adductor The attendant then brings the limb back to the midline alignment while the patient mentally follows the movement Three passive movements are given at one session

Coordination—The attendant sees that no incoordinate movements occur during the process of abduction Particularly must the patient not be allowed to hitch up the pelvis on the side by contracting the abdominal muscles The attendant must also see that contraction is not obtained in any other muscle group during the movement of abduction of the thigh

Muscle Function—When it is determined that mental awareness and coordination have been restored the patient is allowed to perform one active movement at the end of the session, i e, after two passive movements The limb is supported and the movements, guided by the attendant, gradually worked up to three assisted active movements and finally to three resisted active movements

A second position is sometimes desirable in a patient with severe paresis or poor function of the abductor The thigh is flexed to a right angle and the attendant proceeds to restore mental awareness, coordination and function in the manner already described

ADDUCTION OF THE THIGH

For restoration of function of the adductors, the patient maintains the position obtained in abduction of the thigh and the attendant endeavors to restore mental awareness, coordination and function to this group

Mental Awareness —From the position obtained by abducting the limb (Figure 71), the patient is directed to transfer his attention to the adductors of the thigh The attendant indicates the medial aspect of the thigh up to the point of attachment of the adductor longus at the superior ramus of the os pubis The attendant passively restores the limb to the position of midline alignment while the patient mentally follows the movement This movement restores the adductors to their normal resting length

Coordination —The attendant sees that no other muscles contract during the process of restoration of mental awareness to the adductors It must be seen that the adductors of the opposite limb do not incoordinately contract

Muscle Function —When it is found that mental awareness and coordination have been restored, the attendant allows the muscle group to function in performing one active movement (after two passive) The limb is supported and all movements guided The attendant gradually works upward until the patient performs all three movements actively These are first with assistance and later against resistance by the attendant

INTERNAL AND EXTERNAL ROTATION OF THE THIGH

The lower limbs must be maintained in proper alignment of rotation during the treatment period as well as between treatments If the lower limb is noticed to lie persistently in external rotation, the cause of this position must be determined and corrected Spasm of the outer hamstrings will cause the limb to lie in external rotation and the spasm must be treated to enable the limb to be restored to proper alignment If grav

ity is responsible for the limb falling into *external rotation*, a small pad placed to the outer side of the knee will hold the limb in proper alignment

The movements of internal and external rotation are usually performed alternately at one session If one movement can be performed actively by the patient, the attention is focused upon the weaker or non-functioning muscle group The movements will be described separately

INTERNAL ROTATION THE GLUTEUS MINIMUS

The patient is placed supine in normal alignment upon the treatment table and the attendant proceeds to restore mental awareness, coordination and function to the internal rotator

> *Mental Awareness*—The usual procedure of focusing the mind of the patient to the exact *point of attachment of the functioning muscle* is not followed in the case of ball and socket joints, such as the hip (and shoulder) Rotations of such joints is dependent upon the stabilization of the limb by the adjacent hinge joint The patient subconsciously associates rotation with the stable joint, therefore, in restoring function to the gluteus minimus, it is preferable to refer to the knee joint The hinge knee joint is the stabilizing unit for the ball and socket hip joint The attendant focuses the mind of the patient to *the medial aspect* of the knee and passively rotates the limb inward (Figure 72) The patient is instructed to follow the movement mentally but to attempt no physical effort *From the position of internal rotation* the patient is instructed to transfer his attention to the lateral aspect of the knee and the limb is externally rotated passively while the patient follows the movement mentally The move-



Figure 72 The position and grip for restoration of function to the internal rotators of the thigh (In the illustration the movement has already been carried out)



Figure 73 The position and grip for restoration of function to the external rotators of the thigh (In the illustration the movement has already been carried out)

ment is performed three times passively at one session

Coordination —The attendant sees that no incoordinate effort is made to accomplish inward rotation The muscles of the lower leg, particularly at the foot, must not be allowed to attempt the movement

Muscle Function —When the brain path and coordination have been restored the attendant allows the patient to make one active movement at the end of the session of two passive and one active movements The active movements are gradually increased until all three movements are performed by the patient These movements are guided by the attendant, first with assistance and later with resistance

External Rotation *the Quadratus Femoris*

From the position obtained in the action of internal rotation of the thigh (Figure 72), the attendant proceeds to restore mental awareness, coordination and function to the external rotator

Mental Awareness —The attendant focuses the attention of the patient to the lateral aspect of the knee and passively rotates the lower limb into external rotation (Figure 73) while the patient mentally follows the movement The movement is carried out three times at a session, usually alternately with the movement of internal rotation All movements are guided and controlled by the attendant

Coordination —The attendant sees that no other muscle contracts and attempts external rotation of the thigh The foot must especially be watched and any action prevented by requesting

the patient to relax and focus the attention to the proper point

Muscle Function.—When mental awareness and coordination have been established the patient is allowed to make one active movement after two passive movements in the session. The movements allotted the patient are increased gradually until all three movements are performed actively. All movements are guided and controlled by the attendant, first assisting the movement and later resisting.

RESTORATION OF FUNCTION

Muscles of the Leg

THE calf group requires special care and attention because of the frequency of spasm in these muscles Many deformities materialize from neglect of proper treatment of the group and seriously impair the usefulness of the foot and ankle Spasm of the entire group causes direct foot drop and equinus deformity Spasm in the medial head of the gastrocnemius causes a supination of the heel and eventually, if untreated, causes a varus deformity of the foot Spasm of the lateral head of the gastrocnemius causes an abducted heel and eventually a valgus deformity These deformities are uncomfortable to the patient and very disabling They also prevent restoration of function to the muscles of the leg because the disalignment causes certain muscles to be removed from their normal resting length and function to be interrupted as long as the abnormal position persists A position of valgus maintained in the foot, due to a shortened lateral muscle of the leg, will prevent the posterior tibial from returning the foot to normal alignment If the foot cannot be returned to normal midline alignment, the anterior tibial cannot function because it has been removed from its normal resting length It is therefore, understandable that early and intelligent care must be given the patient by

both the nurse and physiotherapist if success is to be achieved in restoration of function to the leg muscles

The standing position or orthograde posture of man is the result of reflex muscular activity induced by con tact of the soles of the feet with a solid surface The tibialis anterior and posterior and the calf group assist in stabilizing the foot, the quadriceps stabilizes the knee, the gluteus maximus and tensor fasciæ latæ sta bilize the thigh, the abdominals and iliocostales lum borum stabilize the trunk and thus the upright posture is maintained The sole of the foot seeks the contact with a solid surface that use has mirrored upon the subconscious mind for years The upright board placed at the foot of the bed as explained in Chapter III, furnishes such contact and is used to assist in re storing the normal proprioceptive reflexes to the pos tural muscles The patient presses the foot against the board and causes impulses to arise in the cutaneous receptors which are transmitted to the proprioceptors and result in stimulation of the standing reflexes This mechanism is impossible when splints or casts are ap plied to the extremities as stimulation of the peripheral receptors ceases to function and impulses are not trans mitted to the proprioceptor nerve endings Physical dissociation of the limbs from the body is suggested in the patient s mind by splinting Mental alienation incoordination and loss of function follow

THE TRICEPS SURAE

(The Gastrocnemius and Soleus)

To restore function to the calf group, the patient is placed supine upon the treatment table The attend

ant proceeds to restore mental awareness, coordination and function to the soleus (see "*First Position* below) and to the entire group (see "*Second Position*' below)

Mental Awareness

(*First Position*)—The limb of the patient is supported by the attendant as shown in Figure 74 The knee is flexed to ascertain whether the soleus has shortened in any way and to temporarily isolate this muscle and allow it to contract The palm of the attendant's hand is placed to the sole of the foot as shown, with the index and second finger to the outer and inner aspect of the heel, to prevent either supination or abduction of the heel [illegible] directs the mind of the patient to [illegible]

and the [illegible]
heel upward from the [illegible]
patient is requested to mentally follow [illegible] movement but to make no physical effort. The attend-
ant returns the heel to normal [illegible] and pas-
sively releases the contraction [illegible] been
brought about by lifting the heel [illegible] Three
movements are given at a session [illegible]
ed by the attendant and are [illegible] as-
certained that function has [illegible] coordi-
nation established

(*Second Position*)—The p[illegible]
pine position but the leg is [illegible] as seen
in Figure 75 The hands [illegible] are
maintained as described f[illegible]
The foot is held at a right [illegible]
The mind of the patient is [illegible]
of the foot owing to the fact [illegible]
full group raises the heel [illegible]
whole weight of the body is [illegible]
of the foot The patient is [illegible]

tendant will lift the heel upward The mind of the patient is directed to the fact that the foot is plantar flexed from three points at the inner, medial and lateral aspects of the ball of the foot The foot is returned to the normal position after plantar flexion Three passive guided movements are carried out at a session

Coordination —The attendant observes whether a greater pressure is felt on either the inner or outer aspect of the ball of the foot If there is a greater pressure, she directs the mind of the patient to concentrate upon the side where the lesser pressure is felt If coordination cannot be obtained, it will be noticed that the heel is either abducted or supinated and that the gastrocnemius needs attention for spasm in the shortened head (lateral or medial) If it is the medial head that is in spasm it will be found that the heel is supinated and that the pressure will be more pronounced on the outer aspect of the foot If it is the lateral head which is in spasm the heel will be abducted and pressure will be felt more firmly on the ball of the great toe

Muscle Function —When it is found that mental awareness and coordination have been restored the attendant directs the patient to perform one active movement at the end of the session, that is, two passive movements and one active movement These are gradually increased until all three are active The attendant guides the movements which are assisted at first and later resisted Individual contraction can be obtained in the medial head by supinating the heel and in the lateral head by abducting the heel Special care must be taken to see that in the effort to plantar flex the foot, the dorsiflexors of the toes are not allowed to contract The deformity of hyperex

INVERSION AND EVERSION OF THE FOOT

(Foot in Neutral Dorsiflexion)

The patient is placed supine upon the treatment ble The attendant stands at the foot of the table d supports the foot by placing her thumb and fifth ger to the forepart of the sole of the foot The tips the remaining three fingers rest lightly upon the dor surface of the foot (Figure 77) The attendant en proceeds to restore mental awareness, coordina n and function to the invertors and evertors of the ot

VERSION

Mental Awareness—The attendant directs the mind of the patient to the attachment of the tib ialis anterior (os metatarsalis I) and supporting the foot as shown in Figure 77 guides and passive ly carries the foot into inversion The patient is directed to follow the movement mentally but to make no physical effort The attendant replaces the foot to normal alignment The movement is passively carried out three times at each session

Coordination—The attendant sees that contraction does not occur in muscles of the foot and leg other than the one for which contraction is sought

Muscle Function—When it perceived that mental awareness and co[illegible] ve been restored, the patient [illegible] one active ffort at [illegible] end [illegible] sess [illegible] r two passive m[illegible]nts [illegible] ot [illegible] d and the ovem[illegible] func [illegible] ovements tted to the [illegible] increased [illegible] move-

tension of the toes will result through this incoordinated effort on the part of the dorsiflexors of the toes attempting to plantar flex the foot

Dorsiflexors of the Foot (at the ankle joint)

(Tibialis Anterior and Peroneus Tertius)

The patient retains the supine position and the attendant uses the same grip as is used for plantar flexion of the foot The attendant proceeds to restore mental awareness coordination and function to the dorsiflexors of the foot

Mental Awareness —The attendant directs the mind of the patient to the point of attachment of the dorsiflexors tibialis anterior to os metatarsalis I and peroneous tertius to os metatarsalis V (Figure 76) The patient is instructed to mentally follow the movement of dorsiflexion which is performed passively by the attendant Three passive guided movements are performed at each session

Coordination —The attendant sees that contraction does not occur in any other group of muscles during the restoration of mental awareness to the dorsiflexors The toe extensors particularly must be observed to see that they do not attempt to assist the movement

Muscle Function —When mental awareness and coordination have been established the patient is allowed to make one active effort at the end of the session i e after two passive movements The attendant supports the foot and guides each motion The active motions are increased gradually to the point where all three movements are performed actively These are assisted at first and later resisted by the attendant

INVERSION AND EVERSION OF THE FOOT

(Foot in Neutral Dorsiflexion)

The patient is placed supine upon the treatment table The attendant stands at the foot of the table and supports the foot by placing her thumb and fifth finger to the forepart of the sole of the foot The tips of the remaining three fingers rest lightly upon the dorsal surface of the foot (Figure 77) The attendant then proceeds to restore mental awareness, coordination and function to the invertors and evertors of the foot

INVERSION

Mental Awareness—The attendant directs the mind of the patient to the attachment of the tibialis anterior (os metatarsalis I) and supporting the foot as shown in Figure 77 guides and passively carries the foot into inversion The patient is directed to follow the movement mentally but to make no physical effort The attendant replaces the foot to normal alignment The movement is passively carried out three times at each session

Coordination—The attendant sees that contraction does not occur in muscles of the foot and leg other than the one for which contraction is sought

Muscle Function—When it is perceived that mental awareness and coordination have been restored the patient is requested to make one active effort at the end of the session, i e after two passive movements The foot is supported and the movement guided and assisted The movements allotted to the patient are *gradually increased* until all three movements are active These move-

ments are at first assisted and later resisted by the attendant

Eversion

The patient remains in the supine position and the attendant retains the grip shown in Figure 77 The attendant proceeds to restore mental awareness, coordination and function to the evertors of the foot

Mental Awareness —The patient is requested to visualize the point of attachment of the peroneus tertius (os metatarsalis V) The attendant supports the foot and guides the foot into eversion The patient is requested to mentally follow the movement The foot is replaced to normal alignment by the attendant Three passive movements are carried out at each session

Coordination —The attendant sees that no other muscles contract other than the one for which function is sought

Muscle Function —When it is determined that the brain path and coordination have been established, the patient is allowed to make one active effort at the end of the session, i e, after two passive movements The foot is supported and the movements guided by the attendant The movements allotted to the patient are increased gradually to include all three as active movements, at first assisted and later resisted by the attendant, until full voluntary function is established

Inversion and Eversion of the Foot

(Foot in Plantar Flexion)

The invertor of the foot when the foot is in the plantar flexed position is the tibialis posterior This

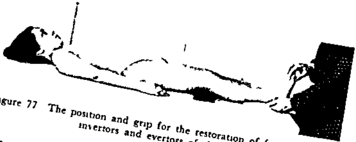


Figure 77 The position and grip for the restoration of function to the invertors and evertors of the foot

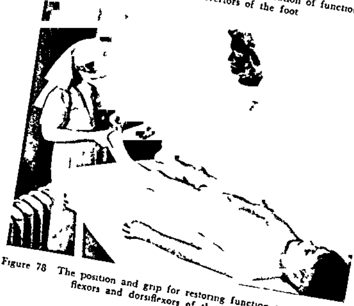


Figure 78 The position and grip for restoring function to the plantar flexors and dorsiflexors of the great toe

is a muscle belonging to Classification II, contracting when removed from its normal resting length When the foot is in eversion the tibialis posterior, having been removed from its normal resting length, contracts to restore the foot to normal midline alignment Thus the tibialis anterior is brought back to its normal resting length The tibialis anterior is a muscle of Classification I, which contracts within its normal resting length for dorsiflexion of the foot When the foot is in eversion the tibialis anterior has been removed from its normal resting length and is unable to give a satisfactory contraction Restoration of function to the tibialis posterior is highly important therefore in preserving the normal mechanism of the foot for walking and also in preventing certain deformities such as valgus foot and flat foot

The evertors of the foot when the foot is in plantar flexion are the peroneus brevis and the peroneus longus The peroneus brevis is a muscle of Classification II, contracting when it is removed from its normal resting length, such as occurs when the foot is in inversion The peroneus brevis restores the foot from *inversion* to normal midline alignment and then in conjunction with the peroneus longus causes the foot to continue into eversion The peroneus longus is a muscle belonging to Classification I and is unable to contract satisfactorily until returned to its normal resting position by the action of the peroneus brevis

In restoring function to these muscles, the patient continues to lie in the supine position on the treatment table The attendant retains the grip described for inversion and eversion of the foot *in the neutral* dorsiflexion position and as illustrated in Figure 77

quested to make the movement actively at the end of the session, i e, after two passive movements The movements allotted to the patient are gradually increased to finally include all three as active movements These are guided by the attendant and are at first assisted and later resisted

Dorsiflexion

From the position obtained in plantar flexion of the great toe, the attendant proceeds to restore mental awareness, coordination and function to the dorsiflexors of the great toe

Mental Awareness —The mind of the patient is focussed to the insertion of the dorsiflexors (base of the second and first phalanges) The attendant proceeds to dorsiflex the toe while the patient mentally follows the movement Three movements are carried out passively at a session

Coordination —The attendant sees that contraction does not occur in any other muscle than the one for which function is sought

Muscle Function —When it is perceived that mental awareness and coordination have been restored, the patient is allowed one physical effort at the end of the session, i e, after two passive movements The movements allotted to the patient are gradually increased to include all three as active movements These are guided by the attendant and are at first assisted and later resisted

Plantar Flexion and Dorsiflexion of the Lateral Four Toes

If the toe muscles are completely non-functioning, the toes may be treated individually as described in the

technique for the great toe Otherwise they are dealt with as a group in unison

PLANTAR FLEXION

The patient remains in the supine position upon the treatment table The attendant proceeds to restore mental awareness coordination and function to the plantar flexors (flexor digitorum longus flexor digito rum brevis quadratus plantæ and lumbricales) of the toes

Mental Awareness—The attendant places the thumb of the right or left hand on the dorsum of the toes and the first and second fingers on the plantar surfaces (Figure 79) The patient is directed to focus his mind upon the ends of the toes The attendant then guides the toes into plantar flexion while the patient mentally follows the movement Three passive movements are given at a session

Coordination—The attendant sees that no mus cles of the foot or leg contract except those for which function is sought

tal

the [illegible] the movement actively after two passive movements. The ac tive movements are gradually increased to one passive with two active and finally to all three active The attendant guides all movements which are first assisted and later resisted

DORSIFLEXION

From the position obtained in plantar flexion of the toes the attendant proceeds to restore mental aware ness coordination and function to the d[illegible]flexors (



Figure 79 The position and grip for restoring function to the plantar flexors of the toes

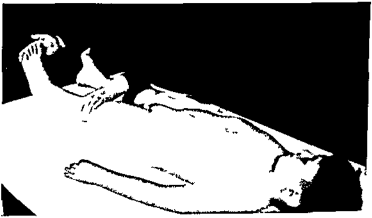


Figure 80 The position and grip for the restoration of function to the dorsiflexors of the toes

tensor digitorum longus extensor digitorum brevis) of the toes

Mental Awareness.—The patient is directed to mentally concentrate upon the ends of the toes The attendant passively guides the toes into dorsiflexion (Figure 80) while the patient mentally follows the movement Three passive movements are given at each session

Coordination.—The attendant sees that a contraction does not occur in any muscles of the foot or leg other than in those for which function is sought

Muscle Function.—When mental awareness and coordination have been restored the patient is allowed to make one physical effort at the end of the session i e after two passive movements The movements allotted to the patient are gradually increased to include all three as active movements These are guided by the attendant and are at first assisted and later resisted

BALNEOTHERAPY

The bath is an important adjunct to the previously described procedures for restoring function to the neuromuscular system after an attack of infantile paralysis Particularly where there is mental alienation of muscles will the bath be useful to assist in the retainment and re establishment of consciousness of these peripheral structures of the body The procedure may be started soon after the time that the re education program has been instituted It should not be used where spasm is present or where moving the patient still arouses fear In those patients who are greatly weakened or debilitated, the warm bath may prove enervating and must be used with caution, if at all Saline baths in the early convalescent stage of the disease aid in toning up the muscle tissue and may be employed especially in the case of those patients who have retained muscle function

It is an important principle of the methods which have been here described that all possible measures be exploited to prevent alienation or dissociation of the patient s mind from his body The use of contrast media, such as may be secured with varying temperatures of water applied to the skin, will serve to help the patient to retain consciousness of his body structures By so doing, it is conceivable that the brain

may be induced to send down impulses to the non paralyzed but alienated muscles in a part where there is active realization by the patient of the part in space Afferent stimuli, set up by this procedure, not only keep the part in the consciousness but may also affect muscular tonus reflexly through the spinal cord The *volume of afferent nerve streams is caused to be in* creased both in the autonomic and somatic nervous sys tems, which tends to keep in action the nervous struc tures still receptive to stimulation and thus reflexly directly affects the tissues under the control of these systems

Circulation *is most surely influenced* in the affected part by the stimulation of vasomotor reflexes through the sympathetic nervous system An improved blood flow will materially aid indirectly in preventing muscular atrophy as well as in avoiding the *damaging circulatory and nutritive changes so fre* quently encountered in the limbs of patients treated by other methods

Balneotherapy, as employed in this work, makes use of two hydrotherapeutic measures in the convalescent patient

1 The immersion bath
2 The cold spray and warm douche

For the purpose of the bath, an ordinary enameled tub five feet six inches long will do for the smaller patients (Figure 81) but a larger metal tub (Figure 83) will be required for the adults The inside dimensions of the larger tub should be six feet long by four feet six inches wide by one foot six inches deep Water connections are made directly with the hot and cold

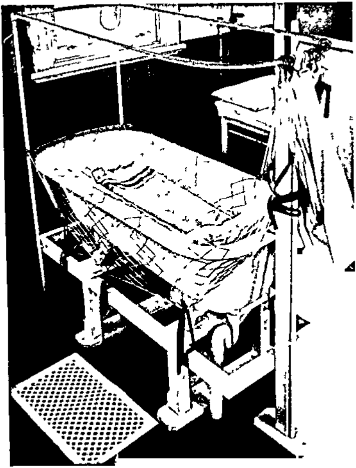


Figure 81 The appointments for balneotherapy treatment for the child patient

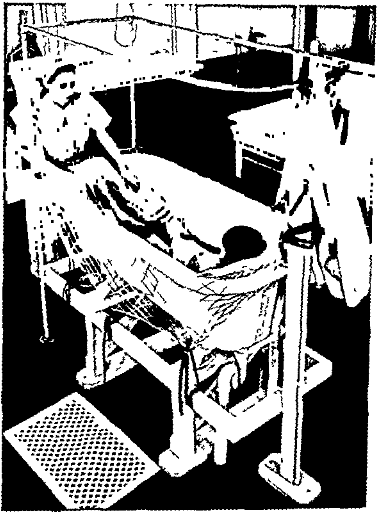


Figure 82 Child patient receiving balneotherapy treatment.

pipes of the water system The cold spray is taken directly from the cold water pipe by means of a length of hose and a spray nozzle For the warm douche a mixer connecting the hot and cold pipes is required to regulate the temperature of the water to be used The warm water is taken by means of a hose connection from the mixer and is used both for the warm douche and for filling the tub The arrangement of these connections is shown in Figure 83 As can be seen in Figure 81, a mesh hammock is secured for use in the smaller tub A piece of blanket or woolen fabric is placed in the center of the hammock and the patient is placed upon this with his head resting on a folded piece of woolen fabric (Figure 82) The larger tub has a rubber bath mat on the bottom upon which the patient lies The head is supported by a folded towel or small rubber pillow as can be seen in Figure 84 The tub is filled with warm water, from underneath the patient, to the desired fullness The bath is enjoyed by the patient and there is promotion of the feeling of health and well being in addition to the general relaxation secured by the warmth of the water The bath is given usually just preceding the re-education exercises on the table, and the patient, after drying, is moved directly to the treatment table

Where extra stimulation is desirable, as in those patients with non functioning muscles, or where there is sluggish circulation the alternate cold spray and warm douche are used The patient is placed in the tub and douched with warm water over the extremities and entire trunk and then treated alternately for the same length of time with the cold spray until each has been used three times This will generally cause a pink tinge

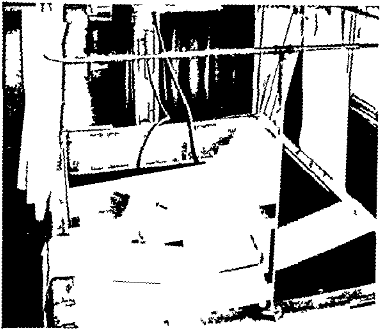


Figure 83 The appointments for balneotherapy treatment for the adult patient

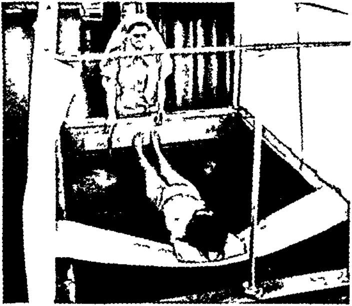


Figure 84 Adult patient receiving balneotherapy treatment

to appear over the skin surfaces, indicating an increased circulation The cold spray is taken directly from the cold water pipe and this usually has a temperature of from 50° to 60° Fahrenheit (10°-15° C) The warm douche should be set for a temperature of 97° Fahrenheit (36° C) The method of applying the spray and douche is indicated in Figure 84 with the attendant standing at the foot of the patient and grasping the spray in one hand and the douche in the other

The attendant douches the patient thoroughly beginning at the feet and extending up on to the abdomen, chest and upper extremities The patient is turned on to his side and douched posteriorly, particular attention being given to the spine The attendant then directs the cold spray in the same manner, proceeding from the feet up on to the trunk of the patient The entire procedure, including douching and spraying each three times, should not require more than a period of five minutes The water is allowed to drain away during this process At the completion of the spraying procedure, the tub is filled by means of the jet of the warm douche and the patient is allowed the warm immersion bath before being moved to the treatment table *No re education procedures are carried out in the bath*

Balneotherapy is not to be confused with pool treatment, the process of re education under water, as has been so widely advocated in the past Pool treatment can have no place in the therapy of infantile paralysis The impracticability and impossibility of its application is evident for the following reasons

1 Immersion in water alters the normal gravitational forces acting upon the body because of the buoyant effect of the water. This is particularly important in connection with structures. The patient finds the necessity of acquiring TIENT in the trunk muscles and to appreciate the mechanism of upright. He is, therefore, tage when he is faced with the direct forces of posture on dry land.

2 The patient water or fearful of directing of the attachments will distracts the cooperation the re education

3 True cannot be is obscured and will freely ones will be will be

4 the

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to the neuromuscular system of the body achieved by properly treating the symptoms and conditions which have been described as characteristic of the disease of infantile paralysis

The various poses which are assumed by the patient in the illustrations demonstrate

1 Spasm has been completely overcome No muscles are shortened There is no stiffness
2 The patient has voluntary control of all his muscles
3 All muscle function is mutually coordinated and synchronous
4 *Normal bodily mechanics have been re stored*

These are not merely acrobatic stunts but an exam ination of paramount importance in safeguarding the future welfare of the patient Particularly is it neces sary to be sure that the patient is able to flex the lower limbs and trunk simultaneously as shown in figure 89 which demonstrates that the posterior body muscles have been relaxed and the anterior muscles restored to function

The ability of the patient to perform the various movements illustrated will be modified somewhat if there has been loss of function of certain muscles or groups of muscles With the assistance of the attend ant most of the postures depicted can be assumed by the patient in all cases where treatment has been properly carried out The movements of the patient are rhythmic and effective even where there has been considerable diminution in muscle power

To the practitioner of medicine faced with the neces sity of treating patients ill with the disease of infantile

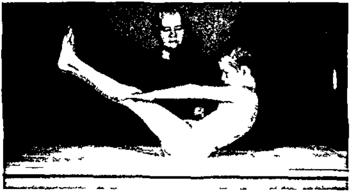


Figure 89 Treated patient To assume the "V" position demonstrates the patient's ability to rhythmically contract all anterior trunk muscles This also proves the strength of the abdominal muscles



Figure 90 Treated patient This position illustrates the rhythmic contraction of all posterior thigh and trunk muscles with stabilization of the parts

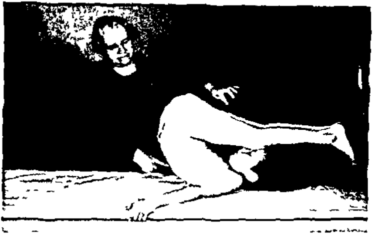


Figure 87 Treated patient This picture shows that all spasm of the hamstring and posterior spinal muscles has been released and that there is no shortening of any of these structures

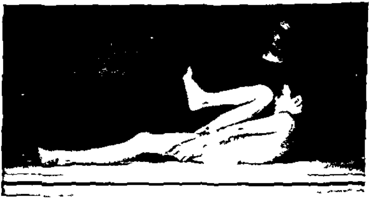


Figure 88 Treated patient The knee to nose position is impossible if there is any stiffness of the spine or any shortening of the spinal muscles



Figure 92 Treated patient The knee to nose position on standing demonstrates the rhythmic flexion of the spine thigh and leg



Figure 91 Treated patient This posture demonstrates that the gastrocnemii and quadriceps are completely relaxed and that no shortening is present If the patient is unsteady or blunders in rising to the standing position the hamstrings are incompletely relaxed or there is lack of coordination between the hamstrings and the quadriceps



Figure 94 Treated patient Standing on the toes demonstrates function of the posterior leg muscles and the absence of shortening of the anterior leg muscles



Figure 93 Treated patient Standing on the heels demonstrates function of the anterior leg muscles and that all spasm and shortening of the posterior leg muscles has been relieved

paralysis in rural or isolated communities where facilities are incomplete, the treatment of the disease as outlined in this book may appear too complex, impractical, or impossible of application with the means at hand. It is true that the complete treatment of this disease requires the services of persons thoroughly acquainted with the mechanics of the body and schooled in the methods of restitution of function to a disorganized neuromuscular system. The necessity of transferring the patient, if possible, to a properly staffed and equipped hospital or clinic as soon as the diagnosis is established cannot be overestimated. Nevertheless, it must be made clear that the treatment of the disease must begin at the earliest possible moment.

This early treatment will consist not of highly technical procedures but of simple nursing, the nursing and solicitous care of sick muscles. Anyone acquainted with the appearance of the body in normal recumbent alignment can determine by visual examination the parts of the body where muscle spasm is present and causing disalignment. A common laundry wringer, woolen blankets and hot water are all the equipment necessary for the application of moist heat to the affected muscles. A word of caution here will not be amiss. The blankets used for foments must be of wool and they must be thoroughly wrung dry of water droplets, otherwise burns will occur. Unless muscle spasm is detected and treated early and intelligently, there will result permanent muscle damage, stiffness, loss of function and deformities. Physical therapy in any form will be incompletely effective and in many cases useless if the muscles are allowed to become short,



Figure 95 Treated patient The heel to buttock posture in the standing position demonstrates rhythmic cooperation between the gastrocnemius and hamstring muscles

PART III

THE CHRONIC STAGE

fibrosed and inelastic for want of proper care in the acute stage It is entirely possible to give such treatment wherever the patient may be found and in whatever circumstance of environment until such time as the patient can be taken to a proper treatment center

It must be re-affirmed, therefore, that there is a treatment for the disease of infantile paralysis This consists first of careful intelligent nursing and second of proper physical therapy The symptoms and conditions characteristic of the disease can be observed by any intelligent medical practitioner, and treatment can be at least started with the simple equipment available in almost every hospital

For the full and complete treatment, the disease requires the closest cooperation between the doctor, the nurse and the physiotherapist

THE CHRONIC STAGE

The Role of Orthopedic Surgery
Artificial Supports

INFANTILE PARALYSIS is a disease whose characteristics in the acute stage are manifested clinically by muscle spasm mental alienation and incoordination For these conditions there is herein described a treatment which, if rigidly followed will markedly diminish the unfortunate sequelæ so commonly observed in the past Deformities were due to the pull of shortened muscles resulting from the neglect of treatment of muscle spasm It is possible to prevent all deformities due to this cause if adequate treatment of the muscle condition is carried out Evidence that deformities are due to untreated muscle spasm rather than to muscle weakness or imbalance as previously believed is presented in Figures 97 to 100

Stiffness is also preventable by treatment of the muscle condition There is no stiffness in joints Stiffness was caused not by proliferative changes and contractures of the joint structures but by fibrosis and restrictive shortening of the associated muscles

The stoppage of growth of the limbs of young children which in the past followed the disease proves to be not explainable by paralysis alone but is more likely due to the constraint of fibrosed muscles attached to

nated action patterns for all muscular activities concerned with posture or motility of the body The rhythm of walking is retained even though there may be considerable loss of actual motive power

Upon completion of treatment there will be some patients who still have weakness or apparent paralysis of muscle, presumably due to destruction of the anterior horn cells of the spinal cord and motor denervation of the corresponding muscle fibers That this is the true state of affairs cannot be refuted even though the pathologist has never been able to strictly correlate the changes found in the spinal cord with that of the loss of skeletal muscle function The action of the virus upon the nerve cell connections and synaptic relationships, quite apart from the effect upon the nerve cell bodies themselves, remains to be investigated It is entirely possible that loss of muscle control or apparent paralysis may largely be due to disturbed physiology or purely functional interruption and blocking of the nervous pathways In support of this theory, the following experience, which is one of many similar observations is presented

Patient D H (Figure 96), a thirteen year-old girl suffered a severe attack of infantile paralysis in September 1940 Muscle spasm was intense throughout the trunk and lower extremities Both lower extremities were apparently completely paralyzed at the onset of the disease With Kenny treatment, power was recovered in the right lower extremity except for the quadriceps which continued to be weak [illegible]
completely [illegible]
The child [illegible]
after the acute illness and to walk with crutches shortly thereafter She had been thoroughly trained in coordination and her gait was rhythmic so that she became able to stand and to walk long distances without fatigue No braces were ever worn Eighteen months after the onset

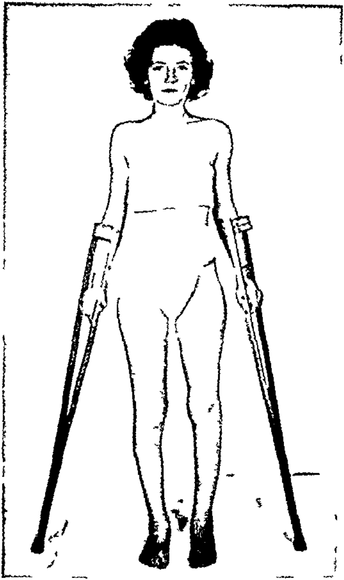


Figure 9[illegible] Patient D H age 13 years The left lower extremity was completely paralyzed and the right quadriceps weak (see case history) Patient has been walking without support except crutches for 22 months Note absence of deformities The growth of the paralyzed leg has progressed normally

of the disease the patient was able to assume complete charge of her mother's household and to care for four younger children. Two years after the disease the patient returned to school and successfully attended classes. The child was repeatedly examined by many doctors but all agreed that there was complete residual paralysis of the left lower extremity. She was seen and examined on November 21, 1942 by a group of distinguished orthopedic surgeons who affirmed the finding of complete paralysis of the left lower extremity including the hip and of weakness of the right quadriceps. On December 1, 1942 the patient fell on the ice. In spite of strenuous efforts the patient was unable to arise from the slippery ground and lay until help arrived some time later. The left knee became flexed due to the injury and the patient was unable to walk. The patient returned to the clinic for examination of the knee on December 3, 1942. It was then discovered that voluntary active power was present in the hip flexor, hip adductor and hip abductor muscles. These muscles were in fact fairly strong.

An explanation for the dramatic return of power to the muscles in the case just cited and in other similar cases cannot be given but it would seem unlikely that the supposedly dead anterior horn cells of the spinal cord could have been so suddenly resurrected by the incident related. It had been accepted that the muscles of the extremity were permanently paralyzed and that the anterior horn cells had been destroyed. The fact that these apparently paralyzed motor units were merely dormant raises the issue squarely as to whether non functioning muscles as seen in the disease of infantile paralysis are necessarily due to destruction of anterior horn cells or are really, in most instances, the result of a physiological block in the motor pathways. The case demonstrates the value to the patient of good physical therapy. The patient had been thoroughly drilled in the correct rhythmic bodily mechanics and the normal walk-

ing pattern was well ingrained in the motor centers, although no actual motor power was present Upon the restoration of impulse to the muscles they were immediately able to resume function because they had been kept soft, full length, elastic and receptive to nerve stimuli Had the muscle condition been neglected in the acute stage the muscles would have been of no value when function later returned

The term chronic applies to those patients who have apparently suffered some permanent and irreversible damage to the neuromuscular system and who in spite of good treatment, exhibit residual weakness or paralysis of muscle Patients exhibiting residual paralysis at the end of the course of treatment will be disabled to the extent of the muscle weakness but this will be relatively of minor consequence providing that the more damaging symptoms and conditions have been adequately dealt with from the onset of the disease The chronic period is generally considered to have been reached when maximum recovery of the neuromuscular system, by treatment of the symptoms and muscle conditions, has been attained This has been arbitrarily set at two years from the onset of the disease but may be longer depending upon the case and the progress Where there is continued return of power in weakened muscles or where hope is entertained of further recovery the patient is considered as still convalescent Where there has been actual destruction of anterior horn spinal cord cells there will be failure of re innervation of the corresponding muscle tissue and a permanent deficit in the total potential functioning motor power of the body Some muscles will be weakened by the loss of a varying number of

hot pack portion of the treatment after three years This case is unusual in that it was possible to secure some relaxation of the shortened muscles even though the muscle condition had been neglected for three years The case is presented not as an example of the value of hot packs applied to shortened muscles, although this is advantageous in some cases, but rather of the effect of shortened muscles in causing deformities In most instances where proper treatment has not been given early in the disease, contractures, which would not be amenable to any treatment except surgical lengthening, would have long since developed

Patient E O This six-year-old boy suffered a supposedly mild attack of infantile paralysis in September 1937. The diagnosis was that of the nonparalytic type of the disease as no muscles were weak or affected in any way as far as could be determined by the routine muscle examination The patient remained in the hospital only thirteen days and was discharged as having recovered Six months later the patient was seen in the orthopedic clinic because of suspected beginning of spinal curvature This was confirmed by x ray (Figure 97) and a reenforced canvas corset was prescribed The scoliosis continued to progress and the patient was admitted to the school for crippled children where he came under the active supervision of the physiotherapist and the attending orthopedic surgeon At this time, a body brace with head support (Figure 98) was applied to the child In spite of daily treatment, including stretching by suspension and of muscular exercises, the scoliosis gradually increased and eventually involved all three segments of the spine in a triple curvature (Figure 99) The parents were advised that fusion of the entire spine would probably be necessary in order to stop the progress of the deformity There was some complaint of painful back The patient was then admitted to the Kenny Infantile Paralysis Ward at the Minneapolis General Hospital in November, 1940, three years after the attack of the disease Hot packs were applied for twelve hours daily to the neck, shoulders and spine on the supposition that the curvature had resulted from the pull of shortened muscles which had

even necessarily disabled providing proper treatment has been given

For those who have suffered severe paralysis, orthopedics offers further hope of rehabilitation In some instances, braces will be required to lend support to the weakened lower extremities in order to facilitate walking A patient with one good leg and one paralyzed leg will walk very well with one or two crutches and will not require any leg brace A patient with two flail legs will require bracing to one or both but will be able to walk satisfactorily providing that there is good power in the trunk The skeleton has inherently a structural stability which is assured by its ligamentous attachments, providing the patient has been taught balance Structural stability is not appreciably dependent upon muscle strength or upon the relative strength of opposing muscles A paralyzed foot with good power above the knee seldom requires any artificial support Permanent residual paralysis or weakness of the trunk is extremely rare and in our experience has never required support The upper extremities never require braces There will never be any reason to apply apparatus for the correction of deformities since there will be no deformities providing that proper treatment beginning early in the disease has been given for the condition of muscle spasm There is no argument for the application of braces to prevent deformities which supposedly would result from muscle weakness or imbalance Deformities do not materialize from this cause Evidence that untreated muscle spasm rather than muscle weakness is the cause of deformities is presented by the following case which did not receive Kenny treatment early in the disease but received the

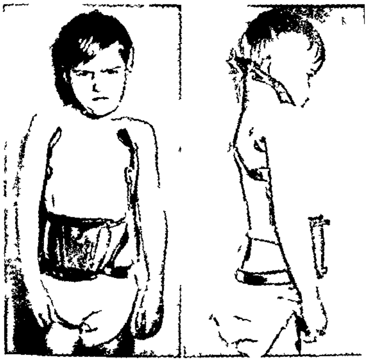


Figure 98. Patient E. O., untreated by the Kenny method. Apparatus worn in the attempt to stop the progress of scoliosis (see case history in the text).

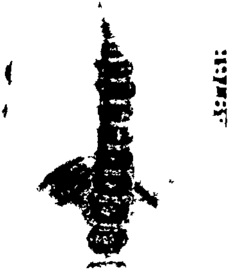


Figure 97 Patient E O non paralytic case not treated by the Kenny method Beginning curvature of the spine six months after the acute attack of infantile paralysis



Figure 100 Patient E O Improvement in spinal curvature after six months hot pack treatment Compare this figure with Figure 99 (condition at the beginning of hot pack treatment) See details of case in the text



Figure 99 Patient E O Triple scoliosis which developed over a period of three years in spite of conventional preventive efforts

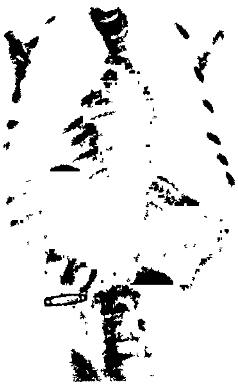


Figure 100 Patient E O Improvement in spinal curvature after six months hot pack treatment. Compare this figure with Figure 99 (condition at the beginning of hot pack treatment) See details of case in the text

originally been in spasm At the end of six months of the hot pack treatment, there had resulted considerable straightening of the spine (Figure 100) No exercises or manipulation of any kind had been given during the patient s sojourn in the Kenny Infantile Paralysis Ward *The child* had not been confined entirely to bed during the hospital stay but was allowed considerable freedom *on the ward The patient returned to the regular publ c* school upon discharge and has since not worn braces of any kind Although fifteen months have now elapsed since the end of the hot pack treatment there has been no tendency for further progression of the scoliosis The child has no complaints and enjoys a much more active and free life than he did before treatment

Finally there will fall to the ingenuity of the ortho pedic surgeon the problem of making most effectively useful the remaining intact or functioning muscle units This will be a pleasant task compared with the experience of the past because he will be dealing with articulations which have a full range of motion and with muscles which are soft, long and eager to respond to stimuli, providing proper treatment has been carried through the entire course of the disease beginning in the acute stage He will have a patient who is not only fully coordinated but also well ac quainted with the procedures of re education The problems of surgery will be somewhat different in that the patient will seldom exhibit isolated paralysis of a single muscle or group With the treatment described in this work, it has been observed that when weakness occurs the muscles of a region such as a complete extremity or of a lower leg, are usually left fairly generally affected or else there is quite uniform re covery in the area The transplantation of muscle will be of value in augmenting those muscles which are most important to the patient but which have been weakened by the effects of the disease Stabilization

of a joint or of a part such as the foot will often make walking easier particularly in clearing the ground if there is a tendency to drop foot Stabilization of joints also offers the possibility of eliminating artificial supports in properly selected cases

COMMENTARY

Miland E. Knapp, M D

Clinical Assistant Professor of Radiology and Physical Therapy and Director of Training Courses in Kenny Technique Medical School University of Minnesota

EARLY in June, 1940, Sister Elizabeth Kenny of Australia was introduced to the medical staff of the University of Minnesota by Dr Wallace H Cole, the chief of the division of orthopedic surgery She had arrived here after a devious course through the United States where she had broached her ideas at various medical centers but had met only polite indifference or outright antagonism Dr Cole, however, being dissatisfied with the results from the prevalent treatment of infantile paralysis, had listened to her with sympathetic ears and had decided that her ideas should be presented to the medical staff for consideration

After listening to a two hour lecture filled with mention of muscle spasm, mental alienation, incoordination, and the like, which I had never before heard associated with anterior poliomyelitis I was so thoroughly confused that I felt it advisable to investigate the subject further After she had demonstrated in my own patients that spasm was present even after eight months of treatment and after I had seen return of function in apparently paralyzed muscles after a few minutes of re-education, it seemed imperative that the matter should be investigated thoroughly

Accordingly, it was decided that patients should be provided upon whom she could demonstrate the value

of her methods and explain her ideas Arrangements were made to have this done at the Minneapolis General Hospital where acute cases would be available Before long a complete ward of twenty two beds was devoted to her work at that hospital and in 1941 a station of seventeen beds was designated for the Kenny treatment at the University Hospital as well

In December 1940, a preliminary report upon the results of the treatment was prepared which was finally published in June, 1941, after becoming probably the most edited paper in medical history It was submitted to the editor of the *Journal of the American Medical Association* who returned it to be dissected by a special committee representing the National Foundation for Infantile Paralysis, Inc It was finally accepted with some misgivings and published with many deletions The ideas contained therein were too revolutionary to go unchallenged

We have now observed this work for two and one half years and have become convinced that the new concept of the symptomatology and effects of the disease is the correct concept and that treatment must be redesigned to conform with these ideas The clinical results are far better than we had been able to obtain by previous methods

Clinical results are, after all, the final proof of the value of any treatment method and it is understandable that the method could be accepted solely upon an empirical basis as long as its results are substantiated Nevertheless the medical mind requires explanations and theories that can interpret these results in terms of pathology and physiology The scientific basis for the Kenny concept of infantile paralysis must now be

sought after with great diligence by those who are qualified to perform research A wide and hitherto unexplored field has been opened for study We must re examine this disease in the light of these findings to determine the real pathologic physiology of anterior poliomyelitis, for only in this way can the afflictions of these sufferers be overcome and the treatment be improved to its highest possible level Sabin writes In reviewing the pathologic physiology of poliomyelitis it may be worth considering the possibility that as regards certain muscle groups the upper motor neurons concerned in initiating voluntary movement may be significantly and predominantly affected I should like to stress the need for a thorough re investigation of the pathologic physiology of poliomyelitis Dr Herman Kabat of the Department of Physiology and I have developed two theories to explain upon a physiologic basis the peripheral manifestations of muscle spasm caused by this central nervous system disease A great deal of investigation will be necessary before these ideas can be proved or disproved But these researches are essential and nothing should be allowed to impede them

The method did not spring full grown from Sister Kenny's mind but was patiently developed through thirty years of keen observation thoughtful study and diligent labor She evolved ideas from observation of cases, considered them and fitted them into the jigsaw puzzle until a rational, meticulous, and completely logical concept of the symptomatology of infantile paralysis and a detailed treatment based upon this concept may now be presented to the medical profession It has not been easy to organize these ideas into an

acceptable form In some instances the presentation may still seem hazy and inconclusive I have been as-sociated with this work since its introduction in this country and have been in charge of the teaching of the method However, disputed points are still gradually clearing up in my own mind so that hardly a week passes without an increase being registered in my own understanding of the method We must continually strive to improve our results by whatever means may be advisable Although the basic principles of the treat-ment have remained the same for thirty years, much work remains to be done to establish the scientific basis for these principles This, I believe, can be done if concentrated effort is applied to the solution of these problems

Upon superficial consideration it would seem that the ideas advanced by Sister Kenny are unphysiolog-ical However, deeper and more detailed thought shows them to be consistent with the best of muscle physiology Much of the opposition to these ideas comes from a conception that has become so ingrained in the medical mind that it is extremely difficult to dis-lodge *This conception is that the destruction of cells* in the anterior horns of the spinal cord necessarily re-sults in a flaccid paralysis, the degree of which bears a more or less mathematical relationship to the number of cells destroyed The effect is too often considered *analogous to the severance of a peripheral* motor nerve These conclusions, however, are not based upon facts Actually, I know of no studies where the amount of anterior horn cell destruction has been correlated sta-tistically or anatomically with the muscle affected or the degree of residual power In fact, Toomey has re-

ported a case where complete clinical recovery followed a case of acute anterior poliomyelitis The accidental death of the patient a short time later permitted pathologic study of the spinal cord which showed marked destruction of anterior horn cells Thus the pathologic findings did not correlate with the clinical condition of the muscles

The Kenny treatment is based upon radical changes in physiologic interpretations of the observed symptomatology of infantile paralysis In large measure these changes in interpretation constitute direct reversals of the relationship of cause and effect This I believe is Sister Kenny s greatest contribution to the study of infantile paralysis

I would like to discuss individually the three basic ideas which differentiate the Kenny concept from the conventional concept of the symptomatology of infantile paralysis and suggest some lines of reasoning and study which might be applied to elucidate the problems confronting us In addition to paralysis which is common to both concepts these are in her own terms muscle spasm mental alienation and incoordination

MUSCLE SPASM

The paralysis from poliomyelitis has generally been considered to be flaccid owing to damage or destruction of motor nerve cells of the anterior horns of the spinal cord Deformities were thought to be due to the muscular imbalance resulting from strong muscles pulling against weaker ones Thus in the conventional conception the primary cause of muscle imbalance was considered to be loss of muscle power Muscle shortening limitation of range of passive motion contrac

tures and other deformities were thought to be secondary and totally preventable by proper splinting and early orthopedic care

This has now been shown to be untrue. Steindler reported that in approximately 25 per cent of his carefully splinted patients contractures of some kind developed. In addition careful analysis of the patient reveals that frequently *the most severe contractures occur in muscles which have no power of voluntary contraction* and are therefore rated as zero. Also careful examination of the patient in the first few days of the disease will reveal that some muscles are already *shortened and painful and cannot be restored to normal length* even by the application of considerable force. This condition does not at all correspond to the condition of true flaccidity following section of a peripheral nerve in which the part can be placed passively in any desired position with great ease in spite of marked inequality in muscle power

These observations support the contention of Miss Kenny that one of the basic symptoms of infantile paralysis is the presence of muscle spasm—an involuntary and uncontrollable shortening of muscle fibers. This spasm is not to be confused with the spasticity of an upper motor neuron lesion which will relax under steady tension

Here certainly is a complete reversal of the idea of cause and effect. Instead of the idea that a more affected muscle allows deformity to occur by giving way to the pull of a relatively unaffected muscle it is now considered that a more affected muscle causes deformity by exerting a positive and often unrelenting pull against a muscle which may or may not be affected by

the disease In other words the deforming force is active instead of passive and therefore requires relaxation rather than support

Scientific evidence indicating the presence of spasm in the muscles in infantile paralysis has been presented in electromyographic studies published by Schwartz and Bouman

The question may well be asked How can this be when the most prominent pathologic changes are in the motor cells of the spinal cord?

Consider for a moment some of the possible mechanisms for the production of the spasm First as to local causes

1 Inflammatory or toxic changes might be present in the muscle itself To the best of my knowledge there have been no extensive studies of pathologic changes within the muscle itself during the acute stage of the disease Thus there is no proof for or against such a possible mechanism

2 Circulatory changes resulting in localized anoxia might be the cause of spasm That circulatory changes do occur in poliomyelitic extremities has long been recognized by the temperature and color changes and evanescent swellings frequently seen Lesions of the sympathetics such as have been found regularly by certain investigators in infantile paralysis might account for these circulatory changes It is well known that muscle pain fibers come entirely from blood vessels so that local anoxia might explain the muscle tenderness as well as the spasm Local anoxia if persistent m[illegible] result in the development of contractures of which [illegible] Volkmann contracture is an example High temperature hot packs with quick cooling such as employe[illegible]

the Kenny technique have been shown to increase mus cle blood flow more than other types of heat

However, it is not necessary to assume that the lo cal condition is due to local causes Changes in the *central nervous system may also account for these* changes in the muscle

1 There may be so called irritative cord lesions to account for spasm This I consider rather unlikely as a major factor, since both spasm and shortening may *be present months or even years after the acute attack*

2 It is well known that denervated muscle is hypersensitive to acetylcholine In infantile paralysis there is an opportunity for an abundant source of acet ylcholine through the uninvolved motor pathways, the *sensory nerves and the autonomic endings Here is an* excellent mechanism whereby local spasms could be caused by pathologic change in the cord Kabat and I have started experiments to attempt evaluation of the part this mechanism may play in the picture of the dis ease *The increased circulation to the muscle obtained* by the packs might wash out the acetylcholine and thus relieve the spasm

3 Kabat has shown that spinal cord anoxia in ani mals produces muscle spasm with pain on pressure or stretching with a distribution very similar to that seen in infantile paralysis The intermediate neurons in the anterior horn of the spinal cord are the cells most affected The physiologic mechanism *by which spasm* is produced in infantile paralysis should be determinable by physiologic experiments and observations in clinical cases It is our hope that such information will simplify the treatment of spasm

4 *It is obvious that the spasm frequently changes*

rather rapidly into contracture, which in time may become irreversible because of fibrous tissue replacement Myostatic contracture due to immobilization or disuse and contracture due to fatigue, ischemia et cetera may all play a part These changes are bound to result in disability due to limitation of motion or due to interference with the available power of opposing muscles

In addition to these purely mechanical disabilities, there is evidence to indicate that prolonged muscle spasm may cause irreversible changes in the muscle itself which might increase the total paralysis in the patient Dolgin and Lehman in 1929, Grant in 1938, Barcroft and Millen in 1939 and others showed that strong contraction of muscles diminishes or completely stops the flow of blood through the muscle In other words, strong static contraction is an anaerobic phenomenon The actual tension of the contracting skeletal muscle is sufficient to stop the flow of blood through it, just as in heart muscle, where it has long been known, there is no flow of blood through the muscle during systole It is during the relaxation phase following contraction that hyperemia is produced in the muscle In infantile paralysis there is apparently a condition in which contraction or spasm may be continuous and unrelaxed not for seconds or minutes but for days weeks, months or even years

This evidence strongly indicates the probability that fibrosis and contractures may be due to anoxia caused by the spasm It also seems reasonable that permanent pathologic changes may thus be produced by the spasm itself, even without extensive loss of motor neurons

Consideration of all these factors concerning the production presence and probable effects of muscle spasm

lends weight to the argument that muscle spasm should be treated as soon as the diagnosis has been made and should be relieved as soon as possible. It also indicates that splinting, which favors the production and continuance of spasm, should be avoided.

MENTAL ALIENATION

The second distinguishing factor in the Kenny idea is the conception of "mental alienation," a term which has brought forth considerable criticism and much debate. It is probably fundamentally a physiologic block in conduction as contrasted with an anatomic block caused by destruction of anterior horn cells. The conditions described by this term undoubtedly include the temporary paralyses produced by nonlethal damage to the nerve cells which recover spontaneously after the subsidence of the infection. However, it includes much more than this, for observation of patients who have been treated only for spasm or who have been treated by conventional methods for some months before the Kenny treatment was started shows that considerable rapid improvement is obtained when the methods of restoring mental awareness and muscle function are commenced. The usual explanation, which is largely psychologic in nature, probably does not cover the entire phenomenon since interference with conduction at synapses or residual loss of function after partial damage to motor cells has been repaired may well enter the picture. Sabin's findings in the cerebral cortex may explain some of this phenomenon.

However, while occasionally paralysis is apparently the first symptom of the disease, it must be admitted that in the great majority of cases the paralysis de-

power rating or at most only a slight increase The increase in useful function is due not to increase in power but to increase in coordination and decrease in limitation of motion from muscle shortening so that the efficiency of the muscle is greater

It is instructive to watch patients who have received this training from the beginning of the disease as they use parts rhythmically and successfully even though the muscle power may be slight

Just what the true physiologic explanation for these phenomena will be, I do not know However, Sister Kenny's observations of symptomatology are absolutely correct and regardless of future developments this much I do know She has knocked us so completely out of our complacent groove of thought about infantile paralysis that some worthwhile advance is bound to result from both her revolutionary ideas and the frantic efforts of her opponents to refute them Those afflicted with the disease stand to benefit in either case, and that, after all, is the objective toward which we are all striving

—MILAND E KNAPP, M D

the process of learning from the most fundamental basis First *the proprioceptive reflexes* are stimulated until muscle tone is observed to be present This indicates that motor pathways are potentially present Second, the *patient is made aware of the location of* the muscle, its function, and direction and location of action And third, the muscle is taught to function in a coordinated rhythmic manner

It is without doubt the best method of muscle re education I have had the good fortune to observe

INCOORDINATION

The third distinguishing idea, incoordination, is easy to describe but rather hard to explain *It merely means* that because of disturbances in the normal motor patterns as a result of paralysis, alienation or spasm, new motor patterns are developed which must be restored to normal before normal action can occur These may show up in the form of substitution which has long been recognized and often encouraged, or in spilling over of impulse to other nonrelated muscles or even to the opponents of the desired action

Also, the normal rhythm of action within the muscle itself may be disturbed so that contraction may occur, for instance only at the origin of the muscle, and the efficiency of the muscle may be greatly diminished

Evidence for the reality of this idea is produced by the numerous patients who have been treated by the Kenny method after months or years of treatment by *conventional methods Many of these* patients have been able to walk without support or have been able to use parts which previously were useless although in most instances muscle tests would show no change in

THE INDEX

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